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BRITISH JOURNAL OF ANAESTHESIA

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EDITORIAL

THE ANAESTHETIST AND HIS EQUIPMENT

IT has been said that a country gets the government it deserves. It might also be said, with equal truth, that anaesthetists get the equipment they deserve.

For far too long, anaesthetists have been content with haphazard methods of administering the powerful drugs they use. This is particularly true when the volatile anaesthetics are vaporized by a gas stream from cylinders or by the patient's respired air in a closed or semiclosed system. The concentrations in which the drugs are being inhaled by the patient are usually quite unknown; and special methods—such as those mentioned in Newman's paper in this issue—have to be set up to measure them.

It is the evanescence of these drugs, rather than any fancied skill of the anaesthetist, which has limited the danger of these unscientific methods of giving volatile anaesthetics. If we were as ignorant of the concentrations of the nonvolatile drugs which we inject, the consequences would be disastrous; and though we must not become dependent on instrumental aids to the exclusion of our clinical judgment, which must remain the final arbiter for our conduct of the anaesthetic, we can no longer be complacent about this deficiency in our equipment. It is no good trying to put the blame on the manufacturers. Within the limits set by their customers, they do a good job.

In engineering and commercial practice, if a piece of equipment has to be made to do a certain task, a specification for it is drawn up. This gives precise information of the requirements to be fulfilled, and specifies the limits, or tolerance, acceptable. If the performance is not up to specification, the equipment is rejected. By this arrangement the responsibilities of the manufacturer and of the customer are clearly defined. But nothing of this sort happens with anaesthetic apparatus. The manufacturers are given little guidance as to what is expected of them; and none at all as to the limits of accuracy required. They seldom adopt the practice, normally followed by the makers of scientific instruments, of issuing an instruction manual, giving detailed information about the construction, operation, performance and maintenance of their product. That they do not do so is because there is insufficient demand from the anaesthetists—for the most part unversed in mensuration and with little interest in engineering—who use their products.

It is easy to find, in operating rooms and anaesthetic rooms throughout the country, anaesthetic apparatus which is in a sorry state, with the paint peeling off it, with loose parts secured by adhesive tape, and with so many leaks that if the hand is placed to block the outlet when gases are flowing, the rotameters continue to indicate a flow of up to a litre a minute. Accuracy and mechanical efficiency are wasted on the users of such machines. It is to be hoped, however, that an increasing number of anaesthetists are taking an interest in the design and efficiency of their apparatus, and are feeling the need for greater accuracy, and higher standards, than have hitherto been demanded of the manufacturers.

The analysis by Hill of the performance of the Fluotec vaporizer, reported in this issue, is of interest in this connection. The instrument is well designed and constructed, and anaesthetists are indebted to its makers for a device which does supply much needed information about the output of a powerful volatile agent. But no measurement, and no instrument, can be absolutely accurate; and just as in scientific papers we expect to be informed about the limits of accuracy of the measurements reported, so in descriptions of apparatus, on which the lives of patients may

depend, we should desire to be told what deviations from indicated performance we may expect, so that we can make proper allowance for them, or condemn the apparatus if we think they are too great.

There are now in Britain a number of research departments whose workers are capable of testing the performance of anaesthetic equipment in terms of safety, accuracy and adequacy of design; and it is to be hoped that in the future manufacturers will seek their advice at an early stage in the development of apparatus. A closer liaison between such departments and the manufacturing organizations would benefit both sides and—most important of all—would make anaesthesia safer for the patient. But the responsibility is the anaesthetists', and the initiative must come from them.

Brit. J. Anaesth. (1958), **30**, 555

HALOTHANE AND REBREATHING

BY

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THIS paper presents some elementary theoretical concepts which, while not necessarily original, have helped the author to substitute clarity for confusion in his own mind and may, perhaps, be of help to others.

Rebreathing can be partial or complete and signifies that part or all of the volume of expired gases is inhaled again at the next inspiration (Annotation, 1954). In the open air, rapid diffusion almost entirely prevents this, but rebreathing occurs, for example, in ill-ventilated spaces such as submarines (Ebersole, 1958) and during sleep, when many animals hide their heads. It also occurs in many anaesthetic techniques. Rebreathing interferes with carbon dioxide elimination so that tissue content of this substance rises, unless a chemical absorber is employed or alveolar ventilation is increased. Rebreathing is used intentionally to conserve expensive anaesthetic agents, such as cyclopropane. Such a financial consideration also applies to halothane, but it has been objected that sudden, fatal overdosage was likely to result if rebreathing were permitted. In an age of "controlled respiration" and "controlled hypotension" perhaps intentional rebreathing during anaesthesia could be styled "controlled pulmonary excretion".

Rebreathing for any gas X can be expressed quantitatively by the fraction $\frac{V_{T_I}\ (F_{I_x} - F_{S_x})}{V_{T_E}\ (F_{E_x} - F_{S_x})}$ where F_{E_x} and F_{I_x} are the average concentrations of X in expired and in subsequently inspired gases respectively, F_{S_x} is the average concentration in which X would be inhaled if there were no rebreathing, and V_{T_I} and V_{T_E} are the inspiratory and expiratory tidal volumes respectively. Alternatively, the concept of external or apparatus deadspace, $V_{D_{app}}$, may be employed and rebreathing can usually be expressed by the fraction $\frac{V_{D_{app}}}{V_{T_E} - V_D}$, where V_D is the subject's deadspace. Total rebreathing occurs when the fractions equal unity. A rigorous exposition of apparatus deadspace is beyond the scope of this paper.

At this point it may be advisable to consider the nomenclature of anaesthetic systems. One can conceive of a system in which inspiration draws gases from and expiration passes gases into reservoirs of infinite capacity. This is the ideal "open" system, in which rebreathing is prevented by diffusion. A mask approaches this system more or less, depending on its construction (Faulconer and Latterell, 1949). Alternatively, inspiration may take place from a finite reservoir, for example, the cylinders of an anaesthetic apparatus (via a reservoir bag), whether of intermittent or continuous flow type. Rebreathing may then be prevented by special valves (Ruben, 1955; Bullough, 1955). In other systems, however, elimination of expired gases is achieved by the flushing effect of large gas volumes flowing during the latter part of expiration and any subsequent pause. The well-known Magill system (fig. 1) is an example of this type, but many others can be designed, for example, the "T piece" (Ayre, 1937) or the arrangement of Bullough (1952). Theoretical considerations (Molyneux and Pask, 1951; Ruben, 1953; Mapleson, 1954, 1957), laboratory experiments (Crowley et al., 1948; Woolmer and Lind, 1954; Harrison and Jones, 1955; Bracken and Sanderson, 1955; Inkster, 1956) and clinical investigations (Davies et al., 1956; de Clive Lowe, 1956; Elam and Brown, 1956) have shown that in these systems large gas flows are required to prevent rebreathing; the smaller the fresh gas flow, the greater being the degree of rebreathing. The relationship is influenced inter alia, by the precise geometrical arrangement of apparatus components. More than a small amount of rebreathing is, of course, harmful and necessitates the use of carbon dioxide absorbents.

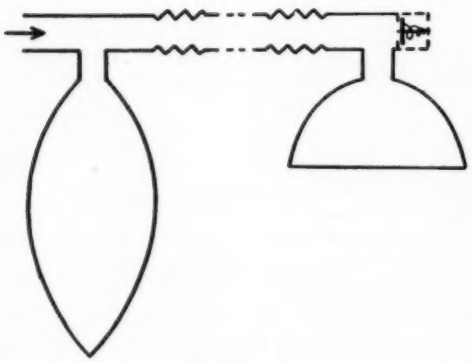

FIG. 1

The Magill system, consisting of a distensible reservoir bag, connecting tubing and a one-way expiratory valve near the face-mask. Fresh gases flow continuously in the direction of the arrow.

Systems which employ total rebreathing are called "closed" and the fresh gas supply is necessarily reduced to the extent of replacing gases abstracted by the patient and apparatus, viz., some 200 ml/min of oxygen and *quanta sufficientes* of other constituents. Subsequent loss of gases through skin or wound does not invalidate this nomenclature, but significant leakage from the apparatus—whether accidental or intentional—should preclude the use of the word closed. The terms "semiclosed" and "semi-open" refer to systems between the two extremes, but, lacking precision, are perhaps best used sparingly.

It is important to remember that the fresh gas flow—and, therefore, the amount of rebreathing—is quite distinct from the geometrical arrangement of apparatus components: valves, reservoir bag, vaporizers, absorber, etc. A circle system may be semiclosed while, on the other hand, a Magill system becomes closed when fresh gas flow is reduced to, say, 200 ml/min of oxygen; its shape is not thereby altered and the necessity for an absorber under these conditions is incidental. For greater clarity, systems are best specified by their components, their arrangement and the fresh gas supply.

Halothane was used originally with fresh gas flows of 10 l./min (Johnstone, 1956). With this method large quantities of halothane are blown into the operating room and are wasted. Wastage can be reduced by rebreathing—partial or complete—utilizing smaller gas flows. For example, Brennan et al. (1957) use a 2 to 4 l./min flow into a to-and-fro system incorporating a Waters canister, but any other arrangement will do equally well and circle systems are used by Stephen et al. (1957) and others.

It is impossible for the concentration of halothane in the system to rise above that in which it is supplied unless other constituents of the gas mixture are abstracted in greater proportion than the halothane. Whereas, theoretically, this will happen when the body reaches saturation, such accumulation can be expected to be slow. Assume, for example, the extreme case in which a closed system is used and all pulmonary excretion of halothane is abolished: suppose that 200 ml/min of 1 per cent halothane in oxygen is added. If the capacity of the entire system of lungs and apparatus is 8 litres, accumulation of halothane would proceed at 1 per cent in 40 minutes, if there were no further uptake. With patient and apparatus uptake continuing, accumulation will be slower still.

As a further example, suppose that a patient is adequately anaesthetized when 4 l./min of 1 per cent halothane are added to the anaesthetic system. Let his exhaled halothane concentration be 0.8 per cent and his minute volume 6 litres. Therefore his halothane uptake is approximately $6000(1-0.8)/100=12$ ml/min. If the system were now closed by reducing fresh gas flow to 200 ml/min, the vapour concentration would need to increase to 6 per cent to provide the same *mass* of halothane. This example draws attention to the need to consider the mass of vapour supplied, rather than its concentration. The effects of drugs generally depend on the tissue concentration, indirectly therefore on the arterial blood concentration. This latter factor is determined, inter alia, by the total mass of drug taken up by the body. To estimate the mass of vapour taken up, however, necessitates knowledge of the concentrations of the vapour in both inspired and expired gas mixtures and of the minute volume. Experience allows us to discard the latter two parameters if the former is known, but the inspired vapour concentration may differ greatly from that at which the vapour is delivered by the vaporizer. Vapour concentrations, by themselves, give little information: 50 per cent halothane

vapour is harmless if only a few millilitres are inhaled and the above example shows that 200 ml/min of 6 per cent halothane added to a closed system may provide light anaesthesia, while 10 l./min of this vapour strength, added to, say, a Magill system, would rapidly be fatal.

Whereas halothane consumption can easily be reduced to some extent by partial rebreathing, it is found that reduction of fresh gas flow through the vaporizer to less than 3 l./min makes it progressively more difficult to vaporize sufficient mass of halothane. The comparatively high concentrations of vapour required under these conditions are beyond the range of efficiency* of reliable vaporizers as available. Complete elimination of halothane wastage by the use of a closed system with "basal" flows of fresh gases requires the use of either

(1) a vaporizer, in the path of fresh gases, of high efficiency; or

(2) a vaporizer situated in such a manner that vaporization is achieved by the flow of the patient's tidal volume.

(1) It is quite feasible to design a vaporizer of high efficiency, although practical considerations such as size, cost and safety introduce certain problems. In particular, the efficiency of the vaporizer should be adjustable in small steps and the adjustment mechanism should be reliable, consistent and gradual in its working. The commonly used Boyle bottle does not satisfy these criteria. Built-in compensatory devices are a welcome luxury but, as the use of potent anaesthetic agents has demonstrated, the fundamental requirement for a vaporizer is a reasonably accurate calibration chart of its output in clinical use. The output of a vaporizer depends on

(*a*) the nature and flow rate of perfusing gases;

(*b*) the design, setting and content of the vaporizer;

(*c*) the temperature of the liquid as affected, among other things, by the mode of previous use.

These factors may act in conflict with each other. At flows just above zero, an increase in perfusion rate causes a fall in output concentration because the gases have insufficient time to take up enough vapour. At higher flow rates increasing vaporization may occur from agitation of the liquid surface. Vaporizers commonly possess a separating device which sends part of the gas flow through the vaporizing chamber proper and diverts the remainder through a by-pass. A changing flow rate may be associated with a change in the proportion into which the separating mechanism divides the perfusing gases. Suppose that one channel is wide and the other narrow. Pressure drop and flow rate may vary differently in the two channels and an increase in total perfusion may divert a greater proportion along the wide channel. Because of the many factors involved, different vaporizers have widely differing patterns of behaviour. The Boyle bottle

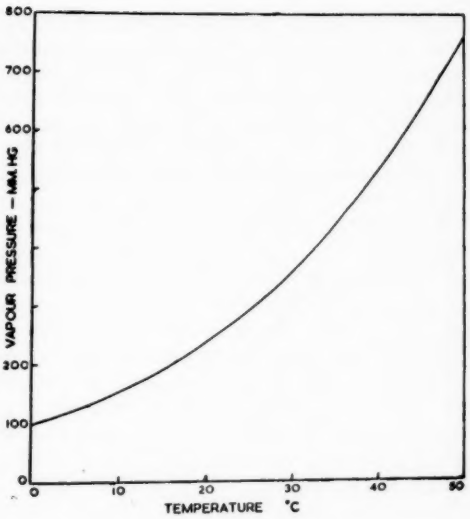

FIG. 2

Ordinate: vapour pressure (mm Hg) of halothane.
Abscissa: temperature (°C).
Modified from Epstein (1957).

* A vaporizer can be considered as 100 per cent "efficient" if gases issuing from it are saturated with vapour at that temperature. Saturation depends on vapour pressure, which, for halothane, is shown in figure 2 for a certain temperature range (after Epstein, 1957). The use of the word "Efficiency" in this manner (for which the author is indebted to W. Edmondson, Esq., of Cyprane Limited) allows various degrees of vaporizer performance to be described. Most vaporizers have an efficiency much less than 100 per cent. Efficiency, of course, refers to a stated setting of any control mechanisms.

generally shows a considerable increase in output concentration as the flow rate is increased (Brennan, 1957). The "Fluotec" vaporizer shows much less variation in output with change in flow rate (over a certain range). Figure 3 presents, as an example, the output from one particular model of a Rowbotham vaporizer containing halothane and perfused with air.

(2) A vaporizer situated so that part or all of the patient's respirations are passed through it, eliminates the problem of falling perfusion rates with increasing degrees of rebreathing and the approach to a closed system. Conventional vaporizers of low efficiency can therefore still be used. Indeed, "inefficiency" becomes a safety factor. However, gas flow through the vaporizer has changed from steady to fluctuating flow and the mass output may not be the same as obtained with the same mean steady flow.

In systems in which there is no rebreathing all the anaesthetic agents in exhalations are wasted. The situation resembles a bath without its plug. In a system with rebreathing and the reduction of wastage, the mass of any agent added to the system must, clearly, be curtailed heavily. The plug has now been put into the bath. This fact may be obvious, yet it is sometimes ignored. Indeed, it is precisely this failure to appreciate the implications of rebreathing which explains the fatal accidents involving halothane in which closed circuits were used in conjunction with efficient vaporizers (Foster, 1957). Drug administration must also be curtailed with progressive accumulation of the drug in the body, but this concept applies to all methods of administration.

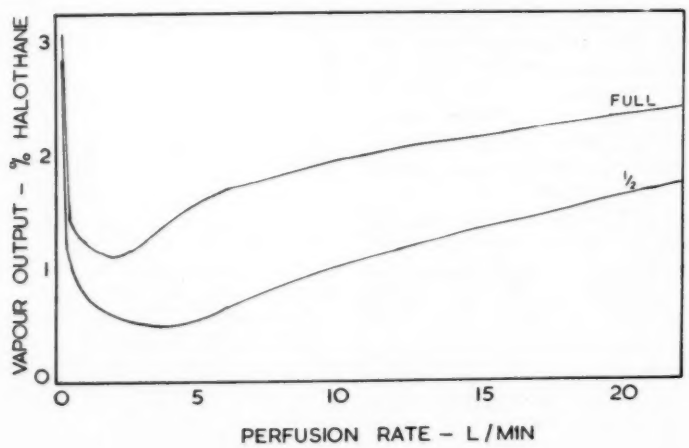

FIG. 3

Ordinate: percentage concentration of halothane issuing from one particular model of Rowbotham vaporizer containing 20 ml halothane at 20°C. (The temperature had fallen to 19½°C at the end of the experiment.)
Abscissa: flow rate (l./min) of room air passed through the vaporizer.

Figure 4 shows the pronounced rise in concentration which occurs when wastage is reduced by increasing the amount of rebreathing. The ordinate shows the concentration of halothane vapour in the inspiratory limb of a B.O.C. Mark II circle circuit.

The patient from whom these data were obtained was a man aged 32 years undergoing inguinal herniorrhaphy under opiate, thiopentone, nitrous oxide and halothane anaesthesia. Halothane was vaporized from a Rowbotham vaporizer containing, initially, 15 ml halothane and situated in the expiratory limb of the circuit. The relief valve was near the face mask. Vaporizer setting and total gas flow (N_2O and O_2) are indicated in the figure. In this and subsequent examples gases were sampled continuously at 1 l./min from the inspiratory limb near the unidirectional valve and, after analysis, were returned to the expiratory limb. The analyzer was of the rapid infrared absorption type, indicating on a dial calibrated

to 4 per cent, with an error of ±0.2 per cent and a response time estimated to be a fraction of a second.

Although the vaporizer was set in the "on" position, the inspired halothane concentration was only just over 1 per cent while wastage was allowed to occur. Elimination of wastage by increased rebreathing led to a considerable rise in halothane concentration almost instantaneously.

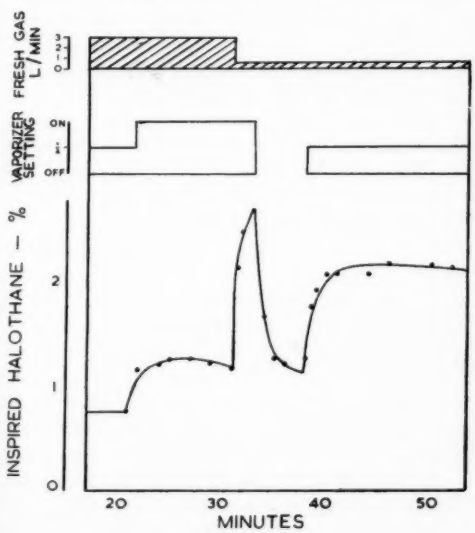

FIG. 4

Ordinate: percentage concentration of halothane in the inspiratory limb of a circle system with a Rowbotham vaporizer containing halothane situated in the expiratory limb. The vaporizer setting and the total fresh gas flow rate of N_2O and O_2 are shown. Note the rapid response to alteration in fresh gas flow rate. The effect of eliminating wastage is much greater than that of changing vaporizer efficiency.

Figure 5 shows the halothane concentration in the inspiratory limb of a B.O.C. Mark II circle system with 5 oz. (150 ml) of halothane in the ether vaporizer of the circle unit. The vaporizer setting is shown. The patient was a woman of 39 years undergoing partial mastectomy under opiate, thiopentone and halothane anaesthesia. Fresh gas flow was 400 ml/min of oxygen. The figure shows how, provided only small amounts of vapour are added with each breath, the inspired halothane concentration reaches a plateau value, at which level patient and apparatus uptake equals vaporizer output. (Apparatus uptake, while easily detected instrumentally, is too small to be of much clinical importance.) The figure also shows that the response to a change in vaporizer efficiency (by altering its setting) is very rapid. Marrett (1957) has also used halothane in a vaporizer designed originally for ether, situated so that vaporization is effected by the patient's respiration; he has used total rebreathing and has described a successful series of 1,500 cases. Chang et al. (1957) have used halothane in the ether vaporizer of a Heidbrink apparatus.

There are, however, certain objections to the use of ether vaporizers for vaporizing halothane. Ether vaporizers are designed to be highly efficient and when used with halothane must be used at their lower range of efficiency, but high concentrations of vapour may nevertheless be obtained by altering the setting. Such an event might occur through ignorance or misadventure and for reasons of human frailty it might be preferable to use a vaporizer of lower maximal efficiency. This could be achieved by using a vaporizer with a smaller surface from which vaporization takes place and by reducing the pathway which the gases traverse and therefore the time of contact with the liquid. A Rowbotham vaporizer satisfies both these criteria and is correspondingly "inefficient". It has been used successfully with halothane by Reinhold and his colleagues (1957) and Gusterson (1957) in a closed circuit and by Burton (1958).* Another way of reducing vaporizer efficiency is to limit the quantity of liquid available for vaporization. This concept is present in drip-feed vaporizers.

Another objection to this use of ether vaporizers is the following (Brennan et al., 1957). In the "off" position the vaporizer may contain air which is saturated with halothane at that temperature (25 per cent at 20°C). If the ports are suddenly opened, air with a high percentage of halothane is presented to the patient at the next inspiration. The total mass inhaled will be large because of the large volume present above the liquid surface in ether vaporizers. This disadvantage may be minimized by utilizing a vaporizer with a small capacity for air above the

* One of the disadvantages of this use of a Rowbotham Vaporizer is its resistance to breathing (Newman, 1958).

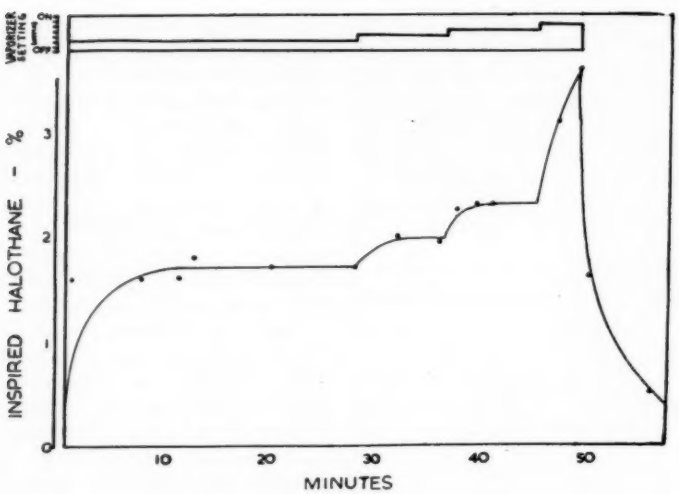

FIG. 5

Ordinate: percentage concentration of halothane in the inspiratory limb of a circle system with halothane in the ether vaporizer of the circle unit. Vaporizer setting was altered in steps as shown. Fresh gas flow: 400 ml/min of oxygen.

liquid, such as a Rowbotham vaporizer. Reinhold et al. (1957) have further improved on this by placing the vaporizer in the expiratory limb of their circle system so that any change produced by alteration of the vaporizer setting is diluted by the gases in the reservoir bag before being presented to the patient.

There remains for consideration an important objection to placing a vaporizer so as to utilize respiratory gas flow. The concentration of vapour in a system depends on the balance of:

(1) the concentration and volume of vapour issuing from the vaporizer (its mass output);
(2) the amount of wastage to the room air (the degree to which rebreathing is avoided);
(3) the uptake by patient and apparatus.

It was pointed out above that the output of the vaporizer is itself dependent on its design, setting and contents, the temperature of the liquid and the nature and flow rate of perfusing gases. When respirations are passed through the vaporizer, the effective flow rate depends on tidal volume, respiratory frequency and respiratory wave pattern. The arrangement of apparatus components determines whether respirations alone or fresh gases in addition are passed through the vaporizer and also affects the temperature of these gases. It is apparent that, even when the components are fixed in position, there remains a multiplicity of variables—some known, others not—which, without direct analysis, makes the estimation of vapour concentration in inspired gas mixtures rather difficult and speculative. On the other hand, such an anaesthetic technique possesses a valuable safety factor, for, when halothane anaesthesia is deepened, minute volume decreases and the vaporizer output is automatically reduced. Conversely, lightening of anaesthesia or increase in tidal volume from surgical stimulation leads to an increase in vaporizer output. This applies, of course, only for spontaneous unassisted respiration.

It may be that a drip feed technique of adding halothane to anaesthetic systems would be economical, safe and would allow accurate estimation of the mass of drug presented to the patient. However, it is for others with greater experience to judge the suitability of different techniques of administering halothane and similar substances. The primary object of this paper has been to

present various considerations which are sometimes ignored and to plead for precision in thought. This plea was not uncalled for. In a report by a special committee to the Medical Research Council, Burns et al. (1957) state: "A closed circuit method was not used (with halothane) . . . in view of the possibility of a rapidly mounting Fluothane concentration". Yet the definition of a closed circuit cannot entail this danger, neither does a bath overflow when the plug is put in: for the water level to rise rapidly, the tap must also be left running fast. The danger of a rapidly mounting halothane concentration is not due to rebreathing, but to a rate of administration of the agent which is excessive for that particular situation. Every anaesthetic technique requires an anaesthetist who is vigilant and who appreciates the implications of whatever procedure he is performing.

SUMMARY

The concepts of rebreathing and apparatus dead-space are considered and their relation to fresh gas flow in anaesthetic systems is mentioned. It is suggested that, for greater precision, anaesthetic systems are best specified by their components, their arrangement and the rate of addition of fresh constituents to the gas mixture. The numerous factors which determine vaporizer output are discussed and attention is drawn to the need to record the position of the vaporizer; when a vaporizer is placed so that it is perfused by the patient's respirations, its mass output is influenced by the minute volume and the pattern of fluctuation of this gas stream.

It is pointed out that when a volatile agent is added to an anaesthetic system, rebreathing itself does not cause a rise in its concentration, except in so far as it conserves that quantity which has been added. Where the vaporizer is placed in the respiratory gas stream, such as the vaporizers of circle units, rebreathing, achieved by restricting fresh gas flow, while minimizing wastage does not reduce the rate of administration of fresh vapour, since the gas flow which perfuses the vaporizer, i.e. the minute volume, is, at first, unaffected. By reasoning and examples, it is shown that constant inspiratory vapour concentrations may be obtained with vaporizers perfused by respirations and in the presence of total rebreathing, provided the vaporizer is set to have a low efficiency. A rising concentration, in whatever system, is due to a rate of administration which is excessive for the particular circumstances. The use of halothane has, by its potency, stressed the need for care and for a knowledge of vaporizer behaviour.

ACKNOWLEDGMENTS

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HALOTHANE CONCENTRATIONS OBTAINED WITH A FLUOTEC* VAPORIZER

BY

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INTRODUCTION

IN view of the wide interest that has been shown in the Fluotec vaporizer, it was thought desirable to measure the halothane output with various gas flow rates and vaporizer dial settings.

The Fluotec is specially designed to deliver stable, known concentrations of halothane vapour. It embodies a bimetallic strip device, designed to minimize variations in the vapour concentration which would result from the cooling of the liquid halothane as evaporation proceeds.

The vaporizing chamber of the Fluotec contains a series of wicks (Edmondson, personal communication) and the vapour emerging from it is nearly 100 per cent saturated. Consequently there is no surge of high vapour concentration when the vaporizer is initially switched on, and the output is unaffected by shaking.

The output control is calibrated from 0.5 per cent to 3 per cent v/v in 0.1 per cent steps. It is impossible to obtain a lower concentration than that delivered at the 0.5 per cent v/v setting, whatever the position of the dial. The calibration is referred to oxygen at N.T.P. as the carrier gas. A full description of the working of the Fluotec has been given by Mackay, 1957.

METHOD

A steady stream of air was obtained from either a cylinder or a pump fitted with a reservoir. After passing through a flow control valve and rotameter the air was delivered to a standard Fluotec vaporizer. The gas and vapour stream emerging from the vaporizer was passed through a baffle system to ensure thorough mixing. Three hundred ml per minute of this mixed stream was sucked through one cell of a Rayleigh refractometer by means of a pump. Copper tubing was used throughout.

The use of a Rayleigh refractometer to measure the concentration of an anaesthetic vapour is well known (Cowan, Epstein and Suffolk, 1942; Jahn, 1955; Edmondson, 1957). In each experiment air was used as the carrier gas and the results subsequently corrected to those which would have been obtained with oxygen at N.T.P. This procedure was adopted because it is that which is employed by Messrs. Cyprane. Calibration factors for air and oxygen were supplied with the refractometer. The correction from ambient temperature and pressure to N.T.P. follows Edmondson (1957).

As a check on the use of the refractometer, for some of the measurements, it was used in parallel with an infrared halothane analyzer. The accuracy of the infrared analyzer calibration was confirmed by Dr. Epstein of the Nuffield Department of Anaesthetics at Oxford. Substantial agreement was observed between the refractometer and infrared analyzer. Figure 1 shows the apparatus used.

For each flow rate in turn of 2, 4, 7 and 10 litres per minute of air through the Fluotec, the dial setting was increased in steps from 0.5 per cent to 3 per cent v/v halothane, and the corresponding vapour concentrations were measured.

In order to obtain reproducible curves it was found necessary to minimize the effects due to the cooling of the liquid halothane contained in the vaporizer. These small effects arise since bimetallic strip devices are not always perfect in their action. From figure 2 it can be seen that the major portion of this cooling occurred in the first 10 minutes after switching on the vaporizer.

* Manufactured by Messrs. Cyprane Ltd.

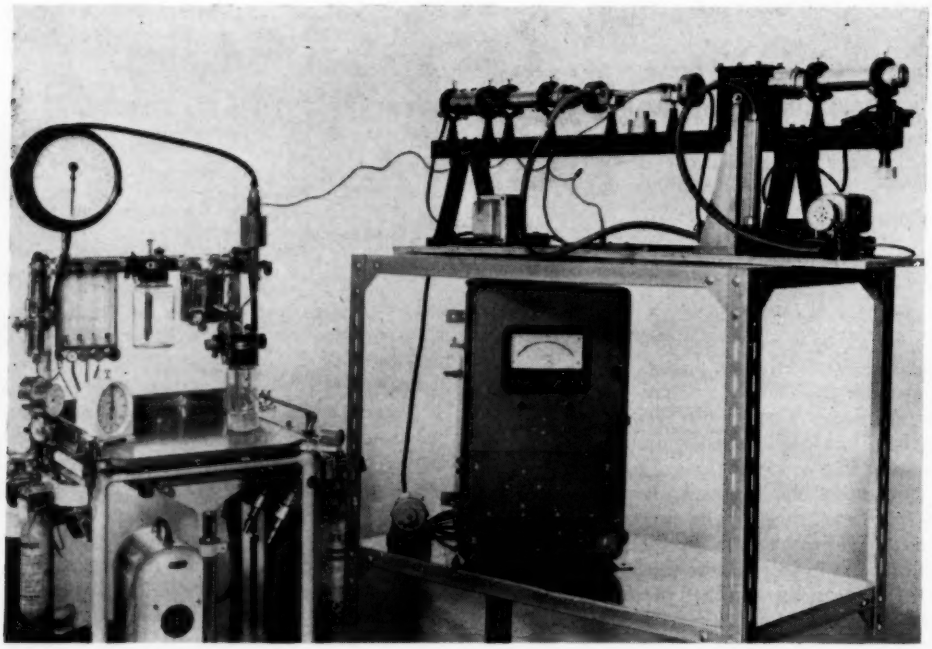

FIG. 1
Rayleigh refractometer and infrared halothane analyzer used in testing the Fluotec vaporizer.

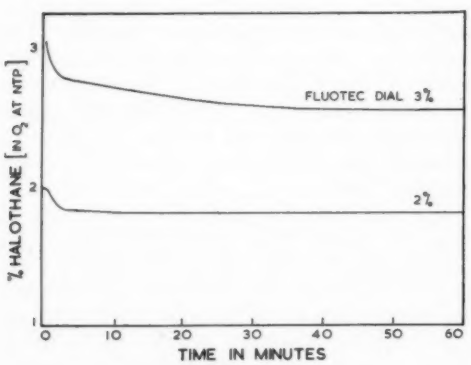

FIG. 2
The variation of vapour concentration delivered by the Fluotec with time.

It was not possible to insert a thermocouple into the vaporizing chamber of the Fluotec to record the actual temperature drop. Before taking a series of readings 10 litres per minute of air were always passed through the Fluotec for 10 minutes at the 3 per cent v/v setting. The level of the liquid halothane in the Fluotec was always maintained at the "FULL" level.

RESULTS

The halothane concentration obtained for the range of dial settings with four different flow rates is shown in figure 3A.

The variation of output with flow rate is considerable with the 0.5 per cent v/v dial setting. For the other settings, at flow rates of 4 litres per minute and over, it is smaller. Figure 4 shows the concentrations recorded for various dial settings, with a range of flow rates from 2 to 10 litres per minute. From the data given in figure 4, it is possible to construct a set of curves comparable with those shown in figure 3A. Such a set of curves is shown in figure 3B. These show good agreement with the experimentally obtained curves of

FIG. 3

(A) Plot of vapour concentration delivered by the Fluotec at different dial settings for a range of flow rates.

(B) Similar plot to fig. 3A but constructed from the data of fig. 4.

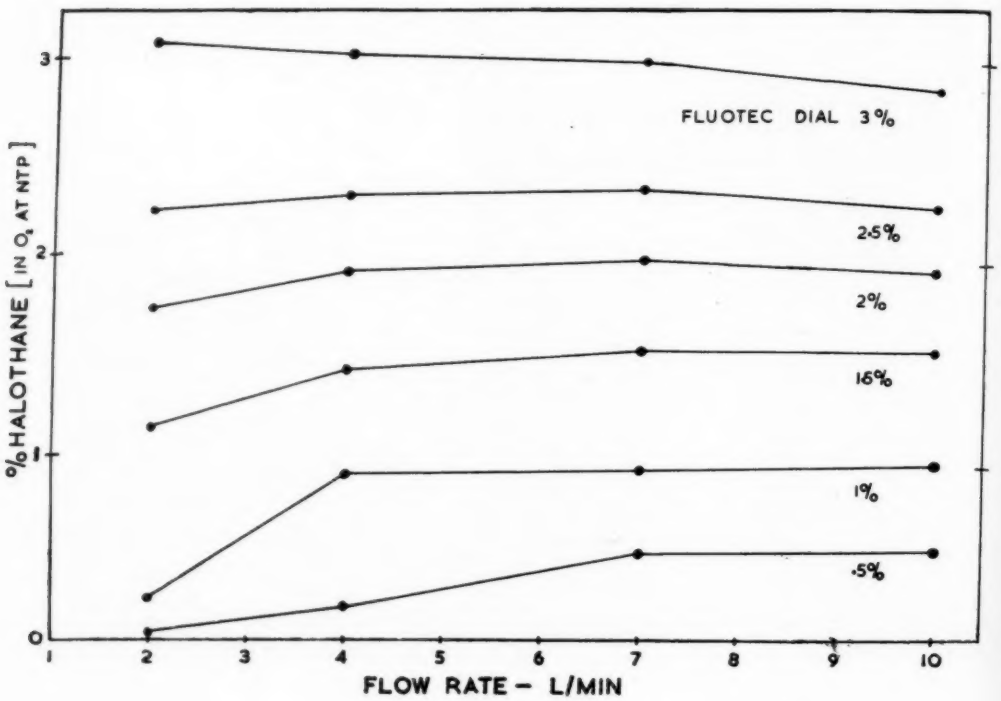

FIG. 4

The variation of vapour concentration delivered by the Fluotec at different flow rates for a range of dial settings.

figure 3A. This is a check on the reliability of the method.

DISCUSSION

From figures 3 and 4 it is seen that there are some inaccuracies in the Fluotec dial calibration. They are more pronounced for the lower flow rates and dial settings. Fortunately, these conditions are not likely to be much used in practice. In closed, or nearly closed, systems with only small flows of fresh gases passing through the vaporizer, a higher output concentration is required. A modified version of the Fluotec is under development to provide outputs of more than 3 per cent v/v at low flow rates.

Messrs. Cyprane Ltd. publish a typical set of vapour concentration versus flow rate curves for dial settings of 0.5, 1, 2 and 3 per cent v/v. These curves show that at gas flows down to 4 litres per minute the dial reads low by at most 10 per cent with the exception of the 0.5 per cent v/v setting which reads low by 30 per cent at 4 litres per minute. The leaflet on the Fluotec also states that it will give good control down to flows of 1 or 2 litres per minute. Messrs. Cyprane are not prepared to quote limits for the variation of individual Fluotecs from their published average curves. This is because of the complicated dependence of the vapour output upon the dial setting and flow rate. However, they will calibrate any individual Fluotec apparatus upon request.

The calibration of the Fluotec is referred to oxygen at N.T.P. as the carrier gas. Edmondson (personal communication) states that for a given dial setting more halothane vapour will be delivered if pure nitrous oxide is used as the

carrier gas instead of oxygen. The variation is not large enough to be important clinically.

The complexity of vaporizer operation is shown by the fact that Epstein (personal communication) has found nitrous oxide to give *less* halothane vapour output than oxygen when used with the E.M.O. inhaler and the Boyle vaporizing bottle. Mackay and Kellow (1958) confirm a maximum variation on any dial setting of ± 20 per cent in the flow rate range 6 to 14 litres per minute. However, apart from the fact that the gas supply was derived from a Boyle anaesthetic apparatus, there is no mention of the nature of the carrier gas used. A Beckman recording spectrophotometer was employed to measure the concentrations of halothane vapour.

The design of the Fluotec has been well thought out and embodies many desirable features. The output stability and ease of control of the Fluotec represent a very considerable advance on the simple type of Boyle vaporizing bottle. Experiments with this simple type of vaporizer could not be carried very far because of its instability. The factors which can affect the vapour concentration delivered by a Boyle type vaporizing bottle have been discussed by Mapleson (1957) and Epstein (1958).

SUMMARY

The halothane vapour concentrations obtained from a Fluotec vaporizer have been measured for various settings of the output control dial and various gas flow rates. The vapour concentrations were measured with a Rayleigh Refractometer and with an infrared analyzer. The error of the vaporizer dial calibration was greater at low flow rates and low vapour percentages.

ACKNOWLEDGMENTS

It is a pleasure to acknowledge the assistance of Messrs. Cyprane Ltd. in lending the Fluotec vaporizer and the calibrated Rayleigh refractometer. Also the Infra-Red Development Co. Ltd. for the loan of the Infra-Red Halothane Analyzer, and I.C.I. Ltd. for a generous supply of halothane. Dr. H. G. Epstein of the Nuffield Department of Anaesthetics, University of Oxford, has kindly checked some of the measurements and contributed much helpful advice.

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Brit. J. Anaesth. (1958), **30**, 568

CIRCULATORY DYNAMICS DURING LIGHT HALOTHANE ANAESTHESIA

BY

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INTRODUCTION

RAPID induction of anaesthesia with intravenous or inhalation agents frequently causes marked hypotension (Johnson, 1951; Dobkin and Wyant, 1957). When these agents are preceded by premedication with a large dose of any of the narcotics, barbiturates or phenothiazine derivatives, the circulatory depression may be alarming. The same applies to rapid induction and to maintenance of anaesthesia with halothane (Raventós, 1956).

There are now many reports of the potent cardiorespiratory effects of halothane (Johnstone, 1956; Bryce-Smith and O'Brien, 1956; Chang et al., 1957; Hudon et al., 1957; Stephen et al., 1957). It was hoped that these could be avoided by using a low concentration of halothane, and that this could provide satisfactory conditions even in those operations normally requiring long and deep anaesthesia.

The following report describes the method evolved to study the circulatory changes during halothane anaesthesia and the results of its application.

MATERIALS AND METHODS

Circulatory dynamics were observed closely in 100 patients undergoing gastrectomy, cholecystectomy and associated procedures, bowel resection, abdominal hysterectomy, abdominoperineal resection, lumbar discoidectomy and spinal fusion. These patients were divided into two groups: those under 50 years (48 patients) and those over 50 years (52 patients). At random, half were premedicated with a phenothiazine derivative and scopolamine, and the remainder received pethedine and atropine. Anaesthesia was induced with a nondepolarizing relaxant, followed by a sleep dose of thiopentone (2.5 per cent) or thiamylal (2.5 per cent). A cuffed endotracheal tube was then inserted under direct vision. This was connected to an Etsten hand ventilator which was driven automatically by a double action piston motor (Dobkin, 1958a). Anaesthesia was maintained in a nonrebreathing system with nitrous oxide-oxygen (2:1) and halothane, delivered from a calibrated Fluotec vaporizer (fig. 1).

The automatic ventilator was adjusted to deliver a fixed volume of the anaesthetic mixture at a fixed rate. The pressure amplitude was set initially at 15 mm Hg peak pressure during inspiration. These parameters were selected according to criteria previously reported (Dobkin, 1958b).

The concentration of halothane was gradually increased, until operating conditions were satisfactory and was later reduced if possible. No case required more than 0.5 per cent halothane for maintenance. Small doses of muscle relaxants were given as necessary.

The arterial blood pressure was determined at 5-minute intervals throughout anaesthesia by auscultation, as recommended by Bordley et al. (1951). It was recognized that in the hypertensive subjects especially, this method of measuring the blood pressure gave a lower value than would be obtained by direct measurement (Van Bergen et al., 1954b). The radial pulse rate was also noted at 5-minute intervals. The electrocardiogram (lead 2) was monitored in most of the patients over 50 (37 patients), and in those under 50 who had signs or symptoms of cardiac disease (11 patients). The stroke volume and cardiac output were estimated in each case from the nomogram of Jackson (1955).

The mean blood pressures and pulse rates during maintenance of anaesthesia were obtained

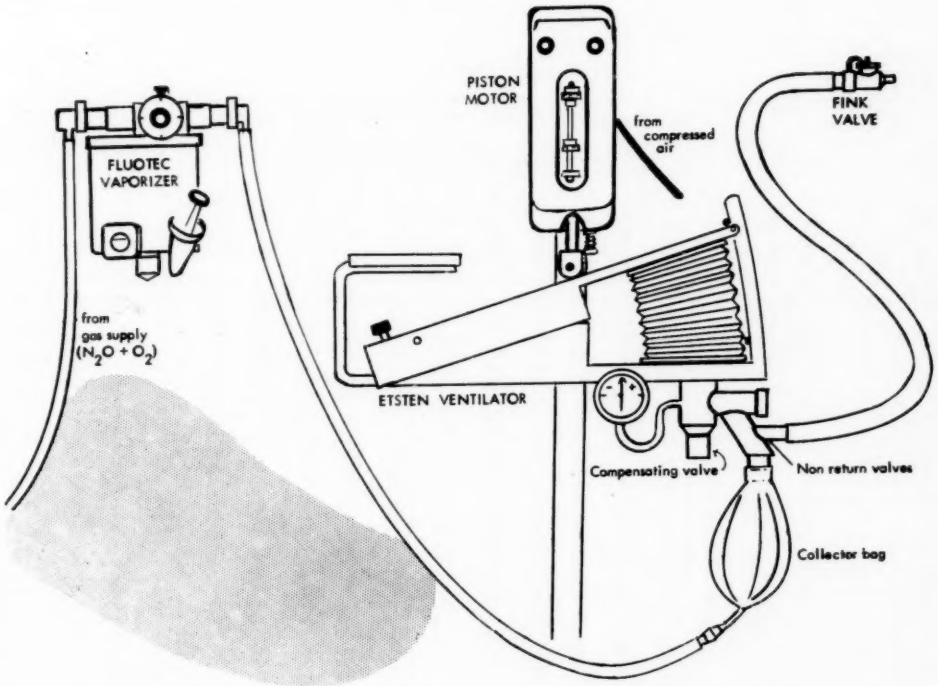

FIG. 1

The inlet of the Fluotec vaporizer was connected to the open circuit of the anaesthetic machine, on which gas flows of N_2O and O_2 were set at a 2:1 ratio. The flow rate exceeded slightly the minute volume of ventilation set on the piston motor (powered by compressed air or oxygen), which drove the Etsten ventilator. The outlet of the Fluotec vaporizer was connected to a collector bag on the Etsten ventilator. After each inspiratory stroke delivered a a fixed volume of anaesthetic vapour through a Fink valve, a like volume passed from the collector bag to the ventilator bellows. When the flow of anaesthetic exceeded the minute volume setting, the excess was vented through the compensating valve.

by averaging the individual readings from the start to the finish of halothane administration.

The lowest blood pressure sustained for a 10-minute period was selected from each tracing, even if it occurred immediately after induction of anaesthesia. The mean pulse rate during this 10-minute period of hypotension was determined also.

In 90 of these patients arterial blood samples were drawn to check acid-base balance and the adequacy of pulmonary ventilation. In none was there any gross disturbance of acid-base equilibrium during anaesthesia (Dobkin, 1958c).

RESULTS

The pertinent data from each patient are contained in tables I and II. Analysis of the variation (standard deviation of the mean) in blood pressure, pulse, estimated stroke volume and cardiac output are shown by means of shading one standard deviation about the arithmetic mean in figures 2 and 3.

Systolic Blood Pressure.

There was a moderate fall (> 15 per cent) in systolic blood pressure in 9 of the 48 younger patients. In 7 patients this occurred immediately after induction of anaesthesia and was unrelated

TABLE I

Circulatory dynamics during halothane-nitrous oxide anaesthesia in a nonrebreathing system and artificial respiration (patients under 50 years).

Patient	Age - Sex	Build	Physical State	Position	Operative Site	Anaesthesia Time	Muscle Relaxant	BEFORE ANAESTHESIA					LOWEST DURING MAINTENANCE					MEAN DURING MAINTENANCE				
								Systolic B.P.	Diastolic B.P.	Pulse Rate	Stroke Volume	Cardiac Output	Systolic B.P.	Diastolic B.P.	Pulse Rate	Stroke Volume	Cardiac Output	Systolic B.P.	Diastolic B.P.	Pulse Rate	Stroke Volume	Cardiac Output
						min		mm	Hg	Min	ml	litres	mm	Hg	min	ml	litres	mm	Hg	min	ml	litres
SL	15F	L	3	Prone	Spine	305	G	100	60	100	77	7.7	84	72	100	55	5.5	94	72	98	61	6.0
KG	19M	L	1	S	ABD	65	dT	120	60	90	86	7.8	86	60	72	68	4.9	108	60	74	80	5.8
YC	21F	L	2	Prone	Spine	370	dT	120	70	80	72	5.8	96	68	80	63	5.1	120	80	68	63	4.2
WF	22M	M	1	Prone	Spine	330	G	118	72	84	68	5.7	80	60	72	62	4.5	96	72	92	58	5.4
RG	25F	M	1	S	ABD	70	G	100	70	72	60	4.4	90	60	100	66	6.6	102	76	100	55	5.5
RN	25M	M	2	S	ABD	145	G	116	70	70	68	4.8	100	70	98	60	5.9	118	80	96	58	5.6
DP	27M	L	2	S	ABD	90	G	122	80	80	56	4.4	122	80	100	60	6.0	130	96	100	46	4.6
JL	27F	M	1	S	ABD	65	M	110	70	66	65	4.2	110	70	72	65	4.7	112	76	60	57	3.5
LH	28M	L	1	S	ABD	140	G	110	70	82	65	5.3	110	70	100	65	6.5	110	80	94	53	5.0
HD	28M	O	2	Prone	Spine	95	M	118	78	70	60	4.2	90	78	70	45	2.7	110	80	74	53	3.9
GB	29F	M	1	S	ABD	105	M	108	60	82	73	6.0	80	50	78	71	5.5	110	70	84	66	5.3
AK	29F	M	2	S	ABD	115	M	110	72	70	61	4.4	100	80	72	47	3.2	120	88	80	48	4.0
IS	30F	M	2	S	ABD	65	M	90	60	70	62	4.4	74	46	72	70	5.0	90	60	70	62	4.4
AN	31M	L	1	Prone	Spine	295	G	110	70	72	61	4.4	100	80	82	45	3.5	110	88	82	50	4.1
AP	32F	L	3	S	ABD	140	G	126	80	88	58	4.2	80	70	92	47	4.3	90	70	78	51	3.9
LC	34F	M	1	S	ABD	195	G	120	80	84	54	4.5	80	60	110	56	6.2	90	70	106	51	5.4
EA	35F	O	2	S	ABD	145	G	120	74	80	65	5.2	110	90	100	38	3.8	118	90	94	42	4.0
MH	36F	M	1	Lith	ABD	80	G	100	56	68	68	4.5	100	56	68	68	4.5	128	86	88	50	4.3
LK	36F	M	1	S	ABD	115	G	100	64	80	60	4.8	100	60	110	65	7.1	110	74	100	56	5.6
DR	36M	L	4	Lat	ABD	75	M	118	70	92	67	5.9	80	56	72	59	3.7	100	60	76	65	4.9
FS	36M	M	2	S	ABD	160	G	120	70	80	67	5.0	100	70	76	54	4.1	110	70	80	58	4.7
GL	36M	M	1	S	ABD	165	M	130	80	100	56	5.6	100	70	84	53	4.5	126	80	84	55	4.6
FC	37M	O	3	S	ABD	130	M	128	70	76	66	5.0	128	70	70	66	4.7	132	84	84	54	4.5
HG	39M	O	2	Prone	Spine	445	dT	96	68	74	53	3.9	78	50	70	63	4.5	94	80	76	40	3.4
FT	39F	O	1	Lith	ABD	115	G	100	76	100	47	4.7	82	66	100	56	5.6	104	74	94	50	4.7
NB	41M	O	3	S	ABD	110	G	114	80	70	45	3.2	110	70	120	55	6.7	130	84	108	48	5.4
VP	41F	O	2	S	ABD	70	G	120	70	72	59	4.3	116	84	98	52	5.1	124	88	94	59	5.5
TS	41F	O	2	Trend	ABD	115	M	110	80	82	44	3.6	92	70	84	45	3.7	124	92	76	41	3.1
WW	41M	L	3	S	ABD	485	G	90	54	62	60	3.7	90	54	62	60	3.7	100	76	82	44	3.7
ZD	41M	M	1	Prone	Spine	185	G	108	78	70	45	3.2	88	72	108	41	4.5	98	80	110	37	4.1
KW	42F	O	2	Trend	ABD	170	G	128	72	110	61	6.8	78	56	96	53	5.1	108	76	90	47	4.3
EH	42F	O	1	S	ABD	105	dT	110	70	100	55	5.5	106	76	70	45	3.3	116	76	72	50	3.7
JZ	42F	O	3	S	ABD	75	G	220	130	100	44	4.4	158	120	100	25	2.5	200	130	104	32	3.3
LH	43F	O	2	Lith	ABD	85	G	130	70	72	66	4.6	84	60	94	53	5.0	100	70	76	48	3.7
JM	44M	M	1	S	ABD	70	G	114	78	62	47	3.0	110	78	90	45	4.1	114	78	90	46	4.2
LS	45F	O	2	S	ABD	105	M	120	70	100	57	5.7	96	70	92	45	4.1	116	76	82	48	4.0
GI	45F	O	2	S	ABD	80	G	100	70	90	48	4.4	100	76	100	42	4.2	110	82	96	39	3.7
AF	45M	M	1	S	ABD	130	G	110	68	100	56	5.6	100	70	100	48	4.8	130	80	100	51	5.1
CC	45F	M	2	S	ABD	110	G	115	70	100	56	5.6	100	70	90	47	4.3	120	80	100	47	4.7
UR	45F	M	1	Trend	ABD	90	M	110	60	108	64	6.9	70	50	104	56	5.8	90	70	92	43	4.0
MB	46F	O	2	Lith	ABD	155	dT	140	76	70	60	4.2	110	70	66	53	3.5	130	80	66	52	3.4
RT	47F	M	1	Lith	ABD	75	G	130	92	86	39	3.3	110	84	110	36	4.0	122	95	96	42	4.0
GJ	47M	M	2	S	ABD	135	M	110	70	76	52	4.0	110	70	76	52	4.0	136	90	62	43	2.7
JJ	48M	O	2	Prone	Spine	330	G	110	80	68	41	2.7	70	54	78	50	3.8	90	70	70	42	3.0
EB	48M	M	2	S	ABD	200	M	128	84	100	45	4.5	80	52	80	56	4.5	122	86	80	40	3.2
GZ	48M	M	1	S	ABD	180	M	110	68	78	53	4.1	110	68	68	53	3.6	130	84	70	45	3.2
AD	49M	M	3	S	ABD	210	G	122	85	88	45	4.0	80	70	84	36	3.4	105	80	90	40	3.6
MC	49F	O	3	S	ABD	100	M	120	80	72	45	3.2	90	68	62	42	3.0	100	70	70	47	3.4
MEAN	37					155		116	73	82	58	4.7	96	68	87	53	4.8	113	79	86	50	4.3
S.D. ±								11	8	13	10	1.1	14	10	15	9	1.1	13	8	13	9	.8

Build:
L = Lean.
M = Medium.
O = Obese.

Position:
S = Supine.

Muscle relaxant:
dT = d-tubocurarine.
M = dimethyl-d-tubocurarine.
G = gallamine.

TABLE II

Circulatory dynamics during halothane-nitrous oxide anaesthesia in a nonrebreathing system and artificial respiration (patients over 50 years).

								BEFORE ANAESTHESIA					LOWEST DURING MAINTENANCE					MEAN DURING MAINTENANCE				
Patient	Age + Sex	Build	Physical State	Position	Operative Site	Anaesthesia Time	Muscle Relaxant	Systolic B.P.	Diastolic B.P.	Pulse Rate	Stroke Volume	Cardiac Output	Systolic B.P.	Diastolic B.P.	Pulse Rate	Stroke Volume	Cardiac Output	Systolic B.P.	Diastolic B.P.	Pulse Rate	Stroke Volume	Cardiac Output
						min		mm	Hg	min	ml	litres	mm	Hg	min	ml	litres	mm	Hg	min	ml	litres
VE	50F	M	2	S	ABD	80	M	130	80	90	48	4.4	110	74	90	45	4.1	122	85	80	40	3.2
HV	50M	M	1	Prone	Spine	120	M	108	70	92	48	4.5	74	62	70	40	2.8	100	80	72	33	2.3
KW	50F	O	3	S	ABD	95	G	110	64	82	55	4.5	90	60	88	50	4.1	116	76	86	46	4.0
NH	51F	O	2	S	ABD	160	dT	108	64	72	56	4.0	80	60	88	45	3.9	104	76	74	50	3.7
JG	52M	M	3	Lith	ABD	95	G	100	70	76	46	3.3	96	70	108	42	4.5	108	70	100	47	4.7
DM	53M	M	2	S	ABD	130	dT	110	58	70	61	4.3	76	30	70	75	5.3	90	56	72	53	3.9
VD	54M	M	3	Lith	ABD	195	M	120	80	72	42	3.0	70	50	70	50	3.5	110	75	74	42	3.1
BH	54F	O	2	S	ABD	185	G	110	50	80	69	5.5	80	50	124	54	6.7	100	64	98	48	4.7
MN	55F	M	3	S	ABD	195	G	128	72	82	53	4.5	110	70	94	48	4.5	130	90	92	35	3.3
AM	56M	M	2	S	Neck	115	G	116	80	68	38	2.5	118	84	110	46	5.1	128	92	114	32	3.6
MB	56F	L	2	S	ABD	200	G	110	70	80	46	3.7	82	60	96	43	4.1	108	68	94	47	4.4
CG	56F	M	3	S	ABD	90	G	126	70	96	54	5.2	100	70	90	41	3.8	130	86	104	38	4.0
EC	57F	M	1	S	ABD	125	G	140	80	80	50	4.0	70	50	88	48	4.2	132	90	84	35	2.9
AL	57M	M	2	S	Neck	70	M	118	86	76	32	2.4	96	76	72	32	2.3	114	80	74	37	2.2
MM	57F	M	2	S	ABD	120	G	170	100	108	43	4.5	116	80	88	38	3.4	150	100	92	33	3.0
RB	58F	M	2	S	ABD	90	G	150	74	94	62	5.5	100	70	92	41	3.8	130	86	98	39	3.7
MB	59F	O	2	S	ABD	110	G	140	90	96	39	3.7	114	76	90	40	3.6	126	80	92	42	3.9
PW	59M	O	3	S	ABD	305	G	120	60	74	61	4.5	90	60	74	45	3.4	110	68	80	47	3.8
AR	60M	O	3	S	ABD	90	dT	118	78	92	39	3.6	80	60	80	40	3.2	98	66	86	41	3.6
SP	60M	O	2	S	ABD	145	M	110	60	76	54	4.1	110	60	76	54	4.1	130	90	66	31	2.0
AM	60M	M	2	S	ABD	250	G	130	90	80	32	2.5	105	84	100	24	2.4	120	90	100	27	2.7
GS	63F	M	2	S	ABD	120	M	124	82	68	36	2.5	116	90	72	24	1.7	130	90	70	30	2.1
CH	63M	O	3	S	ABD	205	G	130	94	80	26	2.1	106	60	92	50	4.6	124	96	90	20	1.8
FS	63M	O	3	S	ABD	185	dT	150	90	92	40	3.8	80	66	90	31	3.0	120	90	80	25	2.0
EH	63F	M	3	S	ABD	110	G	150	100	90	30	2.7	94	70	112	34	3.9	130	100	108	20	2.1
GB	64M	M	2	S	ABD	155	G	120	90	74	25	1.6	116	90	98	24	2.3	136	92	90	31	2.2
CR	65M	M	2	Prone	Spine	300	G	120	80	78	40	2.7	100	64	80	42	3.5	120	80	70	35	2.5
FW	65M	L	2	S	ABD	165	G	108	72	68	37	2.5	90	64	68	37	2.5	115	80	100	32	3.2
TS	66F	O	3	S	ABD	295	G	156	80	72	52	3.8	108	74	60	36	2.2	130	80	66	41	2.5
AM	67M	O	3	S	ABD	90	G	130	72	98	47	4.6	96	70	96	33	3.1	114	78	98	33	3.2
HN	68F	O	4	S	ABD	115	M	160	90	80	43	3.4	90	60	92	40	3.7	120	96	76	18	1.3
CH	68F	L	3	S	ABD	75	G	120	76	74	38	2.6	90	56	80	45	3.6	108	66	80	43	3.4
HL	69M	M	2	S	ABD	240	G	108	72	72	36	3.1	92	68	74	32	2.9	114	84	78	27	2.0
JE	69F	O	3	S	ABD	105	G	142	92	80	33	2.6	132	90	92	29	2.6	140	86	92	37	3.5
AP	69F	L	3	S	ABD	75	G	88	62	100	37	3.7	84	54	100	43	4.3	115	78	100	34	3.4
MC	69F	M	3	S	ABD	90	G	190	70	78	80	6.2	130	70	110	48	5.3	150	80	92	48	4.5
SB	70M	M	4	S	ABD	135	F	100	50	84	54	4.6	60	40	80	39	3.1	90	70	80	22	1.8
LA	71M	M	2	S	ABD	155	G	130	70	72	46	3.4	130	70	72	46	3.4	136	80	80	37	3.0
JT	71M	O	3	S	ABD	150	M	150	80	72	45	3.2	94	60	70	39	2.9	160	84	66	46	3.0
MR	72F	M	3	Lith	ABD	80	G	154	80	88	47	4.1	154	70	88	58	5.1	156	96	86	30	2.6
CL	74M	O	4	S	ABD	240	G	128	90	100	25	2.5	74	54	108	37	4.0	118	72	100	37	3.7
NN	74F	M	3	S	ABD	90	G	140	100	100	18	1.8	120	90	98	19	1.9	140	100	100	18	1.8
AS	74M	M	2	S	ABD	155	G	120	90	72	19	1.5	110	74	82	31	2.5	124	82	86	30	2.6
HT	75F	M	4	S	ABD	115	G	140	70	84	49	4.1	80	40	72	52	3.8	130	64	74	50	3.7
MB	75F	O	4	S	ABD	100	G	160	110	156	16	2.5	110	88	100	16	1.6	150	118	100	15	1.5
IH	75F	O	3	S	ABD	70	G	160	74	70	55	3.9	120	60	108	50	5.3	160	70	82	59	4.8
FT	75M	M	2	S	ABD	190	G	140	86	92	31	2.9	100	80	104	19	2.0	110	84	96	20	1.9
EC	76F	O	3	S	ABD	185	M	126	74	78	38	2.9	90	72	80	23	1.8	110	76	78	27	2.1
FS	77M	O	3	S	ABD	125	G	150	90	120	33	4.0	116	80	114	25	2.6	136	92	104	23	2.4
ME	77F	M	3	S	ABD	210	G	130	70	74	43	3.1	120	70	80	38	3.0	140	94	80	23	1.8
JB	78M	O	2	Lith	ABD	175	M	146	90	72	29	2.0	120	80	68	28	1.7	140	84	62	33	2.0
MT	79F	O	3	S	ABD	220	M	130	68	100	45	4.5	90	54	70	40	2.8	130	80	70	31	2.2
MEAN	65					110		130	78	84	43	3.3	100	67	88	39	3.4	124	83	86	35	3.0
S.D. ±								20	13	15	13	1.1	17	11	14	11	1.1	17	11	12	10	.9

Build:
L = Lean.
M = Medium.
O = Obese.

Position:
S = Supine.

Muscle relaxant:
dT = d-tubocurarine.
M = dimethyl-d-tubocurarine.
G = gallamine.

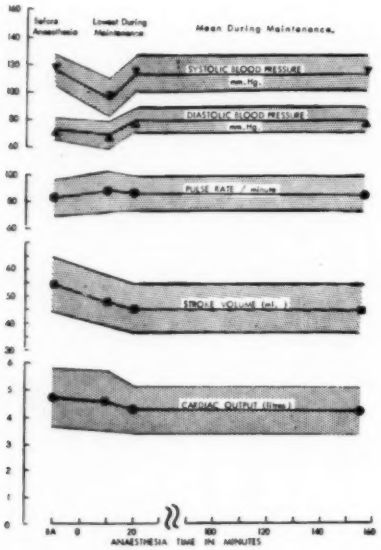

FIG. 2

The mean circulatory effects of light halothane anaesthesia observed in 48 patients with a mean age of 37 years during relatively long major surgical operations (mean 155 minutes). Systolic blood pressure was unchanged while diastolic pressure was elevated slightly, resulting in a reduced pulse pressure and estimated stroke volume. There was no consistent change in the pulse rate or estimated cardiac output.

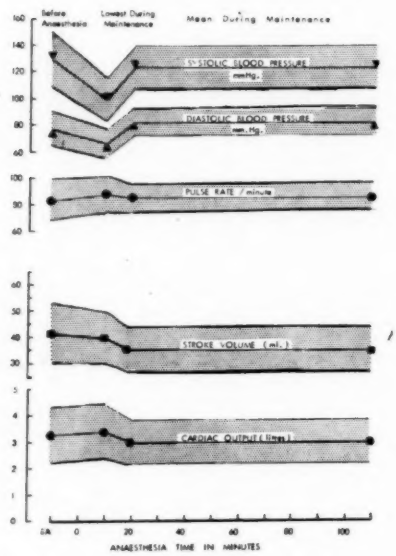

FIG. 3

The mean circulatory effects of light halothane anaesthesia observed in 52 patients with a mean age of 65 years during relatively long major surgical operations (mean 110 minutes). Changes observed were essentially the same as in the younger group.

to the effect of halothane. In 4 of these the pressure was restored with methoxamine, and in 3 it rose spontaneously within a few minutes. The systolic pressure in 2 others fell later. In one of these the pressure recovered when the concentration of halothane was reduced; in the other, the concentration was maintained and the patient failed to respond to lanatocide C (Cedilanid[R]) and atropine, but 12 minutes later, when the halothane was turned off, the pressure rose promptly (see fig. 4).

There was also a moderate fall (> 10 per cent) in systolic blood pressure in 11 of the 52 older patients. In 4 of these, the fall occurred immediately after induction of anaesthesia and returned spontaneously. In 2, the fall coincided with the introduction of halothane, and was restored promptly with lanatocide C (see fig. 5). Of the remaining 5, 1 was treated with lanatocide C and 4 with methoxamine. Each responded promptly.

Diastolic Blood Pressure.

Except for the period of hypotension which occurred immediately after induction of anaesthesia, the diastolic pressure did not fall, and in the majority of patients tended to rise slightly.

The most noticeable observation with respect to the arterial blood pressure was the reduction of the pulse pressure. This was reflected in the moderate reduction in stroke volume, and the slight decrease in cardiac output during maintenance of anaesthesia.

Pulse Rate.

The pulse rate decreased (> 10 per cent) in 19 patients and increased (> 10 per cent) in 29

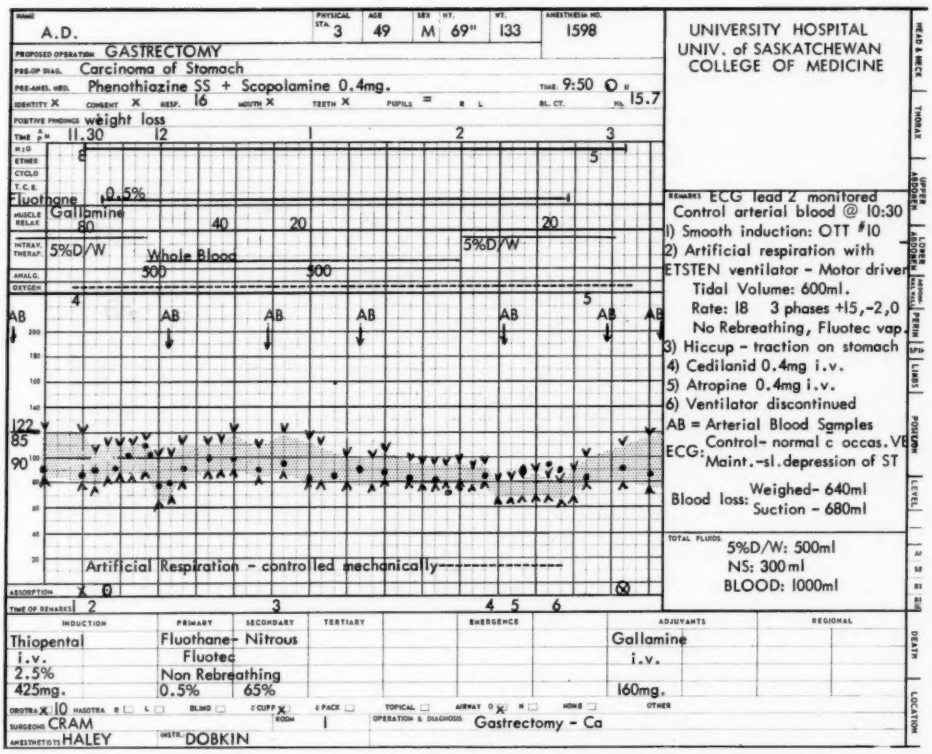

FIG. 4
Anaesthetic chart. Observe hypotension and reduced pulse pressure which developed after 140 minutes of anaesthesia with 0.5 per cent halothane and 65 per cent nitrous oxide.

patients. In the group as a whole there was no significant alteration in the pulse rate.

Electrocardiogram.

In none of the 11 younger patients did a major disturbance appear at any time. One of these patients had ventricular extrasystoles when the pre-operative record was taken, but these did not appear during anaesthesia.

Three of the older group with auricular fibrillation pre-operatively, had no alteration in the e.c.g. during the anaesthetic. Two others had runs of ventricular extrasystoles and a nodal rhythm, which disappeared after administration of atropine. One patient developed S.T. depression which persisted until the anaesthetic was discontinued. In another patient, extrasystoles seen pre-operatively disappeared after induction. No abnormal tracings were seen in the remaining 30 elderly patients. One of the 15 older patients, on whom no e.c.g. was recorded, developed a bigeminal pulse which persisted briefly even after atropine.

Artificial Respiration (I.P.P.).

There was no evidence that the use of the automatic mechanical ventilator with I.P.P. produced serious cardiovascular depression even when phenothiazine derivatives were included in the premedication of 36 younger patients and 14 older ones (see fig. 4), or when the patients were hyperventilated (see figs. 6 and 7).

DISCUSSION

Whenever a new anaesthetic agent is introduced into clinical practice, initial reports of its effect

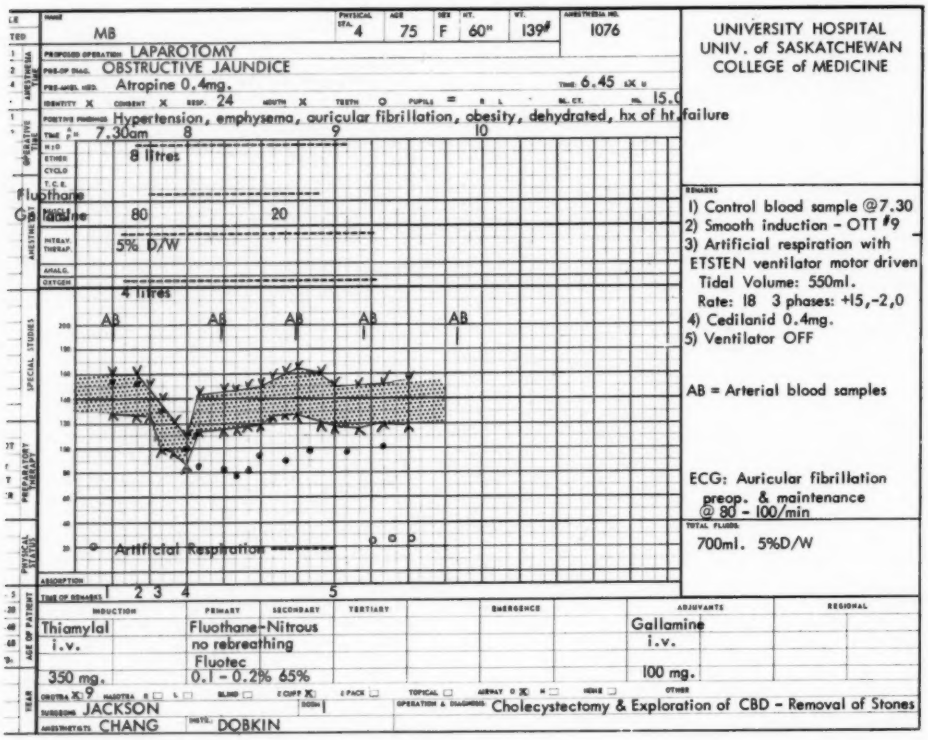

FIG. 5

Anaesthetic chart. Observe that the blood pressure and pulse did not change during first 7 minutes of anaesthesia after induction (thiamylal 350 mg and gallamine 80 mg), then there was an immediate gradual fall when Fluotec was turned on to 0.2 per cent. The fall continued down for 15 minutes. Then lanatocide C (0.4 mg) was given i.v. This promptly restored the blood pressure. The quantity of halothane administration was not changed until closure of the abdominal wall was started.

on circulatory dynamics may express a variety of opinions reflecting a variation in the methods of administration rather than in its actual properties.

Halothane anaesthesia undoubtedly causes a characteristic depression of the human heart. When inhaled in excess of 1 per cent, the pulse rate is slowed, and the arterial blood pressure falls as the concentration of halothane is increased. The arterial blood pressure may stabilize if the concentration is increased no further, but may also fall to a very low level (Raventós, 1956; Johnstone, 1956; Bryce-Smith and O'Brien, 1956; Robson and Sheridan, 1957). The lengthening of the duration of cardiac systole associated with bradycardia is indicative of a predominant depressor nervous or cholinergic humoral influence. When this is accompanied by a decrease in the force of systolic contraction, there is usually an elevation of the venous pressure and increased diastolic size (Wiggers, 1952). Such a response is common when more than 1 per cent halothane is inhaled. This alteration in circulatory dynamics is similar to that seen during hypoxia, auricular fibrillation, insufficiency of the heart valves, and hypertension.

When surgical stimulation occurs during halothane anaesthesia, the blood pressure and pulse rate usually stabilize at a higher level, but remain

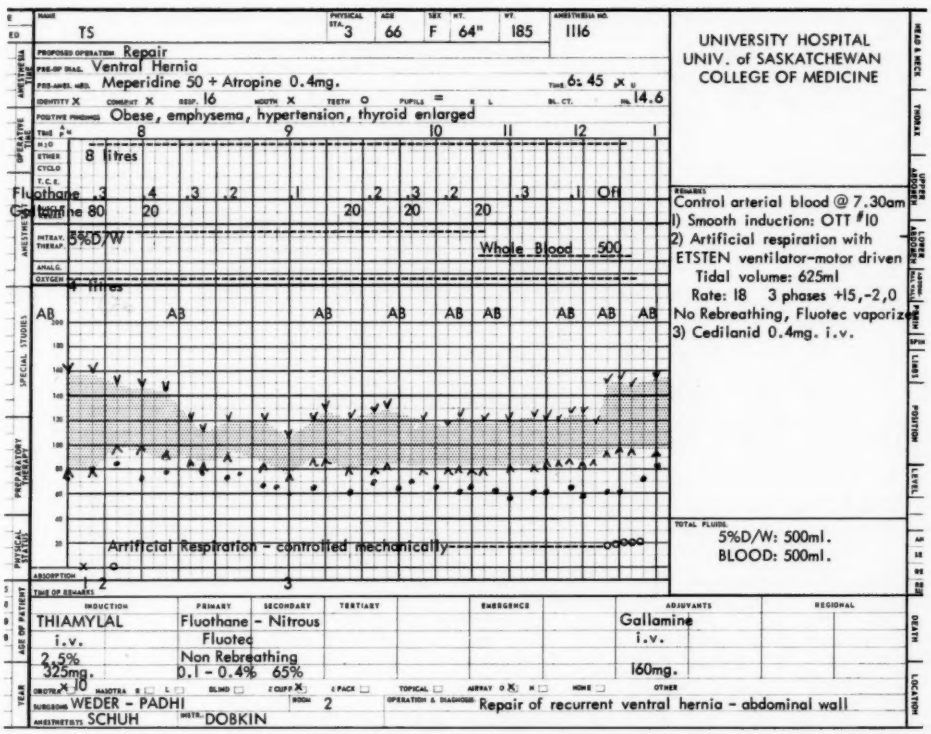

FIG. 6

Anaesthetic chart. See text and comments under figure 7.

below the normal level. The patients have dry warm extremities and a full pulse. The veins are distended and the pupils are contracted. These effects resemble those of chlorpromazine (Dobkin et al., 1954) more than hexamethonium (Van Bergen et al., 1954a). There is also depression of conduction in the heart at the sino-auricular node, so that ectopic centres discharge and nodal rhythm or ventricular extrasystoles are not uncommon. Ventricular arrhythmias are seen particularly if induction to a deep level of anaesthesia is rapid. Cardiac asystole has been reported when deep anaesthesia was allowed to persist (Raventós, 1956; Johnstone, 1956).

Anaesthesia with 1.5 per cent halothane causes a significant reduction in arterial pressure, stroke volume and cardiac output due primarily to myocardial depression. This effect was shown by comparing the effect of halothane before and during sympathetic blockade produced with trimetaphan or high spinal anaesthesia. An infusion of phenylephrine was used to stabilize the blood pressure at the control level. The cardiac depression was accompanied by a slight rise in venous pressure and peripheral resistance. The circulatory effect was less pronounced after atropine (Severinghaus and Cullen, 1958). This work confirmed the results of animal experiments which showed that halothane was a weak ganglionic blocking agent, and caused hypotension mainly by myocardial depression (Burn et al., 1957).

In most of the patients reported here, even when extensive cardiorespiratory disease was present, there was no serious cardiovascular depression because the concentration of halothane inhaled did not exceed 0.5 per cent. Light pre-

Patient TS Hosp.# 31940 Age 66 Sex F Ht. 64" Wt. 185# BSA. 1.88 Physical State 3

Anaesth.# 1116 Premed.: Mep. 50mg., Atr. 0.4mg. Anaesthetics: Thiamylal 325mg., Gallamine 160mg., Build: Obese
Nitrous - Fluothane

Pulm. Vent.: Method- Etsten Mach.,NR. Amplitude; • 15,-2,0 Phases: 3

Blood Pressure: Preop.: 156/80 During Anaesth.: 110 - 130/ 80 - 100 Postop.: Steady

Ventilation Data	Control								Postop.
Time	7:30	8:15	9:15	9:45	10:15	10:45	11:45	12:15	12:50
Tidal Volume	SR	625						625	SR
Rate	20	18						18	22
Minute Volume		11.2 L						11.2 L	
Arterial Blood Data	Room air /			General	Anaesthesia				/ Room air
Hgb.	14.6								
Hct.	45	46	45	45		43	42		42
pH	7.35	7.49	7.46	7.45	7.47	7.45	7.45	7.38	7.33
Total CO_2 content mM/L	18.6	15.8	16.0	16.1		16.0	16.2		18.1
Plasma CO_2 content mM/L	23.2	19.8	20.0	20.2		20.0	19.8		22.6
Plasma HCO_3^- mM/L	21.9	19.0	19.2	19.3		19.1	19.0		21.3
pCO_2 mm.Hg.	42	27	28	29		30	29		44
% O_2 saturation	88	100	100	100		100	100		93

Summary & Remarks : Ventral Hernia Repair. Supine Horizontal Position. Anaesthesia was maintained for 295 minutes with Nitrous Oxide 65% Oxygen 35%, and Fluothane 0.2 - 0.4% in a non-rebreathing system with the Fluotec vaporizer. Arterial blood pressure remained steady for 40 minutes after induction at 150/90, then gradually fell over the succeeding 50 minutes to 110/70. Cedilanid was then administered intravenously (0.4mg.) and the blood pressure rose to 130/90 where it remained fairly steady until the t end of the operation. When anaesthesia was removed, the blood pressure rose to 160/100. Although the operation was long and difficult due to multiple hernial sacs, the maintenance of anaesthesia was smooth throughout. Postoperative course was uneventfull.

FIG. 7

Protocol of ventilation and arterial blood data. Observe that this elderly patient was hyperventilated moderately on account of her obesity and emphysema.

medication with narcotics or phenothiazine derivatives, and intermittent positive pressure artificial respiration, even with moderate hyperventilation, did not cause apparent depression of the heart. In any case, depression of blood pressure cannot be attributed to pulmonary ventilation which is adequate or slightly in excess of normal (Raab, 1929). Where depression of circulatory dynamics under the same circumstances has been reported, greater concentrations of halothane were used (Chang et al., 1957; Hudon et al., 1957; Stephen et al., 1957).

In the patients with heart disease, any tendency toward marked hypotension was checked promptly with lanatocide C. The low incidence of cardiac arrhythmias in this study may be attributed to the satisfactory pulmonary ventilation provided in each case (Scherf et al., 1955).

There was no general tendency to slowing of the pulse. This may be attributed in part to the fact that all the patients received atropine or scopolamine pre-operatively, and that 5 of the younger and 15 of the older patients received a supplementary dose of atropine after about $1\frac{1}{2}$ hours of anaesthesia. Another factor which would tend to prevent bradycardia was the use of gallamine as the muscle relaxant in most of these patients (65).

In a few patients halothane anaesthesia was accompanied by an elevated pulse rate and a fall in pulse pressure (as was seen in patient A.D. shown in figure 4). This change may have been indicative of peripheral circulatory insufficiency caused by an inadequate blood volume. Halothane must therefore be administered with great care in patients with insufficient blood volume (Johnstone, 1956).

The nondepolarizing relaxants used did not show marked variation in their tendency to lower the systolic blood pressure, possibly because hypotension occurred in only a few cases in this study. However, it did appear more likely with d-tubocurarine or dimethyl d-tubocurarine than when gallamine was used.

Thus, halothane may affect the circulation adversely, even in low concentration. It has been suggested that the addition of diethyl ether might prevent this, as in the case of cyclopropane. Hudon and Jacques (1958) have reported on the use of a constant boiling mixture of halothane-ether (68.3:31.7). This is almost as potent as halothane, is nonexplosive and noninflammable (in less than 10 per cent vapour concentration), and there is no cardiovascular depression if it is used in less than 1.5 per cent concentration. This mixture is being tested by the author, and already appears to be superior to halothane alone.

SUMMARY

Light anaesthesia using halothane and 65 per cent nitrous oxide was administered to 100 patients. A nonrebreathing system was used with a Fluotec vaporizer and artificial respiration was provided by an automatic mechanical ventilator. Conditions were satisfactory for major operations. There was little tendency to hypotension or bradycardia provided that the patient received an adequate dose of atropine. The vagolytic action of gallamine may also have been of value in this respect. However, there were still a few patients who became moderately hypotensive and required supportive drugs such as lanatocide C and methoxamine. This hypotension has led to trials of a constant boiling mixture of halothane and diethyl ether, which appears to provide satisfactory anaesthesia without myocardial depression.

ACKNOWLEDGMENT

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HALOTHANE AS AN ADJUVANT TO NITROUS OXIDE IN OUTPATIENT DENTAL ANAESTHESIA

BY

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NITROUS oxide has been extensively used as a general anaesthetic for outpatient dental extractions for many years. Its advantages include its rapid induction, the speedy complete recovery, its relative pleasantness to inhale, the convenience of its administration, and its long record of safety. It has, however, well-known defects, among which is lack of potency, which makes it necessary to add an element of hypoxia to give sufficiently speedy induction and adequate anaesthesia to be acceptable in practice. The dangers of hypoxia, particularly to the elderly and the unfit have recently been demonstrated, and disturbing reports of permanent neurological sequelae have been published (Bourne, 1957; Bedford, 1955). In an attempt to overcome these dangers methods have been devised for giving nitrous oxide with higher concentrations of oxygen (Tom, 1956; Mostert, 1958) but these have not universal application, and some supplementary drug may be required.

Attempts have been made to find additives which enhance the gas's potency and permit the accompanying hypoxia to be reduced, but retain the advantages. Intravenous techniques are available using barbiturates such as thiopentone, but they are strictly contra-indicated unless administered by those well versed in their use, and are often not available to the dentist for this reason. Other disadvantages are that they add greatly to the recovery time and to the accommodation for recovery which must be provided, and that the perils of anaesthesia are increased, particularly in less skilled hands. It was hoped that buthalitone might prove more suitable but recent work has shown it to be inferior to thiopentone (Simmons and Blanshard, 1957). Premedication, either by injection or orally, using pethidine, opiates, barbiturates or ataractics, again increases the time taken in recovery and the patient is rarely fit to leave unaccompanied for his home or work after these drugs have been exhibited.

Among the relatively satisfactory agents have been cyclopropane and trichloroethylene. Cyclopropane delays recovery, and the patients feel less well than after nitrous oxide. It is explosive and there is a danger from its ignition by sparks from dental forceps (Newton-Andrews, 1954; Bourne, 1954). Its administration with 50:50 nitrogen-oxygen or with helium mixtures in an attempt to overcome this requires special apparatus and is a technique not available to most anaesthetists or dentists. Trichloroethylene is relatively satisfactory with few after-effects and only slightly raised incidence of vomiting. It can easily be added to the gases delivered from a standard anaesthetic machine, it is cheap and it has a good safety record, but it too is relatively weak.

It was considered that the ideal drug should be volatile, easily administered from standard apparatus, nontoxic, safe and able to provide subjectively pleasant anaesthesia with recovery as rapid as from nitrous oxide alone. It should be nonexplosive, require no premedication and cause as little pharmacological disturbance as nitrous oxide, while being sufficiently potent to permit reduction or abolition of the hypoxia associated with a straight "gas". At the same time it should give smooth anaesthesia in the resistant patient. The drug would probably be required to do all this in supplementing nitrous oxide, and not to provide the greater part of the anaesthesia in its own right. It was thought that halothane might fulfil some of these criteria.

Halothane is volatile and nonexplosive. Its potency has been described as twice that of chloroform and four times that of di-ethyl ether (Raventós, 1956). Recovery from full surgical

anaesthesia is usually rapid, while secretions are not stimulated and its use is infrequently followed by vomiting (Johnstone, 1956; Bryce Smith and O'Brien, 1956). The Medical Research Council investigated 245 patients who received halothane anaesthesia and they found that the drug caused no greater liver or kidney dysfunction than other anaesthetics, which has been confirmed by other authors. Its pharmacological actions have been shown to include hypotension, bradycardia and respiratory depression with tachypnoea, and some authors (Brennan et al., 1957) regard the bradycardia as potentially dangerous, advising pre-operative injection of atropine, whilst they and others (Johnstone, 1956; Mackay, 1957) confirm a consistent fall in blood pressure and its sensitivity to posture. The above publications refer mainly to full general anaesthesia for in-patient surgery and little has been published on the use of halothane for outpatient dental anaesthesia.

It has been shown that unsupplemented nitrous oxide-oxygen in the dental chair usually produces a moderate rise in blood pressure (Goldman et al., 1958), but it was thought that halothane might induce undesirable hypotension when given in this position. The bradycardia, the respiratory depression, and any delay in recovery were considered possible disadvantages, and the trial was designed to assess all these factors.

METHOD

An unselected series of 300 patients undergoing outpatient extractions at the Royal Dental Hospital under general anaesthesia was divided into three equal groups. Each group received nitrous oxide-oxygen, nitrous oxide-oxygen-trichloroethylene, and nitrous oxide-oxygen-halothane respectively. The gases were supplied from a standard Walton Mk. II machine and ordinary nasal administration was the rule. The machine was set in every case to deliver a continuous flow of gases with the foot control at the halfway mark, and the induction was with 100 per cent nitrous oxide. For the administration of halothane and trichloroethylene a small Rowbotham's vaporizer was inserted between the machine and the reservoir bag 10 ml of the drug in question was placed in this and was used until exhausted. For giving halothane four or five breaths of pure N_2O were given, and then the vaporizer turned on to the $\frac{1}{4}$ mark; five breaths later this was increased to $\frac{1}{2}$. For trichloroethylene a similar technique was adopted, but the control was advanced rather beyond the halfway mark. Oxygen was added in all cases in the usual way once nitrous oxide anaesthesia had become established.

In view of the bradycardia reported after the administration of halothane a small pilot series was carried out. Patients were given atropine 1/100 grain (0.6 mg) intravenously 5 minutes before the nitrous oxide-oxygen-halothane. No patient developed bradycardia and the full series was then carried out without any premedication.

A sphygmomanometer cuff was applied to the arm after the patient had settled in the dental chair, the systolic blood pressure was measured by palpation at the wrist and the pulse rate was recorded. The patients were briefly questioned about their health to bring to light any grave pathology, but were not examined unless their replies indicated this to be desirable. Any notable medical conditions revealed here were recorded, and so was the anaesthetist's assessment "Good", "Poor", or "Resistant". If not "Good", reasons were given. The assessment with regard to the resistant patients was based upon the patients' physique, their experiences of previous anaesthetics, their habits, their temperance and the general clinical impression they gave. Afterwards the anaesthetic was recorded as either satisfactory or unsatisfactory, with reasons given for the latter. This again was a clinical evaluation for which no precise criteria were sought.

The time from the start of induction until the removal of the mask at the end of operation was recorded as the duration of anaesthesia, and the interval from then until the patient was able to leave the chair and walk supported to the next room was recorded as the recovery time. An attempt was made to assess further the recovery time by recording the interval between the end of the operation and the patient's leaving hospital. It was, however, found that this was related less to the anaesthetic than to the time for the extraction site to be regarded as satisfactory, and the bleeding to cease. The administrative delays associated with the patient leaving hospital also make this measurement valueless for

assessing recovery from anaesthesia, and it was discontinued.

Patients were visited in the recovery room and their postoperative condition was noted under the following headings: Good, Vomiting, Nausea, Headache, Drowsiness, Dental Complications, Others.

Children under the age of 5 years were excluded from the trial because they could not be consistently relied on to accept nasal induction, and because other agents such as vinyl ether or ethyl chloride had sometimes to be used.

RESULTS

The changes in blood pressure with the three techniques are shown in table I. It is of interest that the concentration of halothane used had little effect in modifying the rise in blood pressure associated with nitrous oxide anaesthesia, despite the use of the sitting position. This applies to both normotensive and hypertensive patients.

Alterations in pulse rate are shown in table II. Again there is no significant difference between the three techniques, and no evidence of bradycardia caused by halothane.

The records of duration of anaesthesia plotted against recovery time in table III show no correlation between the two factors, but both supplementary drugs increase the time of recovery.

Eighty per cent of those receiving nitrous oxide-oxygen alone, or supplemented by trichloroethylene, left the chair 2 minutes after the end of the anaesthetic. A similar proportion of those receiving halothane left in 2¼ minutes.

However, 80 per cent of the anaesthetics with halothane are completed in 3 minutes, while a similar proportion of those receiving either unsupplemented nitrous oxide or trichloroethylene as additive required 4 minutes to be completed. It is possible that this can be explained by the easier operating conditions provided by halothane. Halothane caused less salivation than trichloroethylene, while the relaxation of the jaw muscles it provided was excellent. It was usually possible to position the dental prop to suit the progress of multiple extractions using only the fingers when halothane was given, a manoeuvre requiring a mouth-gag and possibly some force and trauma under the anaesthesia provided by unsupplemented nitrous oxide, or with trichloroethylene.

Cases whose postoperative conditions were not regarded as "Good" are indicated below.

Nitrous oxide-oxygen.

Three patients drowsy for some minutes after operation.

Nitrous oxide-oxygen-trichloroethylene.

Five patients with pulse irregularities due to extrasystoles at the end of operation.

Two patients vomited, one of whom had hiccough, and one was drowsy as well.

Three patients unduly drowsy after operation.

Nitrous oxide-oxygen-halothane.

One patient (age 12) vomited and was drowsy.

One patient (age 9) regurgitated swallowed blood after operation.

One adult complained of nausea.

Two patients (both aged 12) were drowsy.

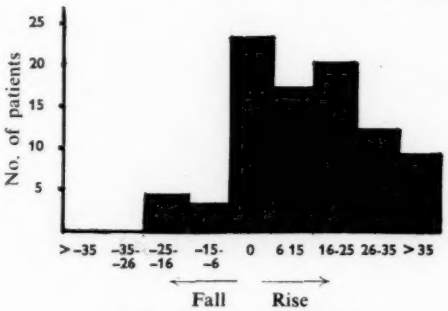
One young man receiving trichloroethylene developed symptoms similar to the "faint" under anaesthesia described by Bourne (1957). The anaesthetic was at once discontinued and the patient placed supine while oxygen was administered—at this time the pulse rate was 48/minute, and the systolic blood pressure 60 mm Hg. Recovery was rapid and complete and the extraction was completed later with the patient supine with no ill effects.

One young woman receiving halothane developed clonic movements of the limbs accompanied by moderate dilatation of the pupils. There was no evidence of hypoxia at this stage, and the movements were not those of jactitation. Her pulse, respirations and blood pressure remained normal. She regained consciousness in the usual time, and recovery was rapid and complete. Later questioning revealed that she had "convulsions" as a baby, and "blackouts" as a child. It is possible that all these phenomena were epileptic.

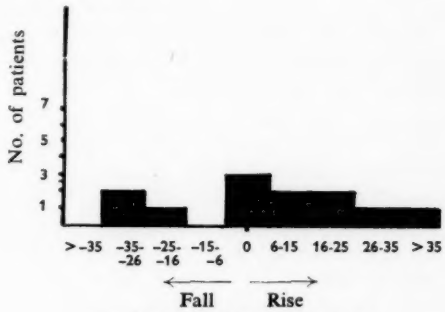
All patients left the hospital in the usual time, and there were no untoward sequelae to anaesthesia or to extraction, except for one boy aged 12 who had received unsupplemented nitrous oxide for the removal of $\frac{E \mid E}{E \mid E}$ and who returned later that day for further treatment for haemorrhage from the operating site.

TABLE I

Unsupplemented Nitrous Oxide-Oxygen.

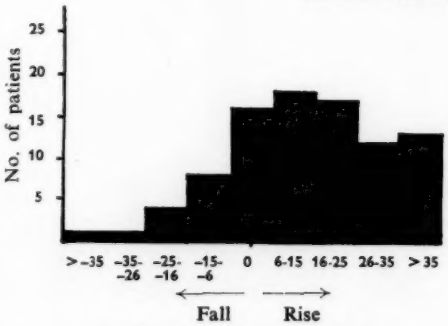


mm Hg change in systolic B.P.
Normotensive patients.
Systolic B.P. 150 mm Hg or below.

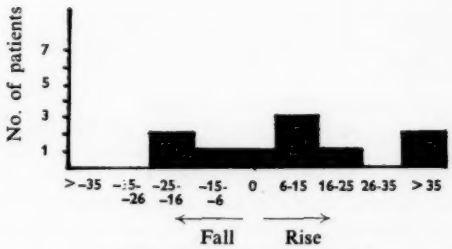


mm Hg change in systolic B.P.
Hypertensive patients.
Systolic B.P. 151 mm Hg or above.

Nitrous Oxide-Oxygen-Trichloroethylene.

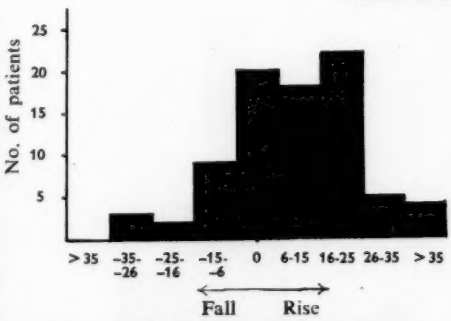


mm Hg change in systolic B.P.
Normotensive patients.
Systolic B.P. 150 mm Hg or below.

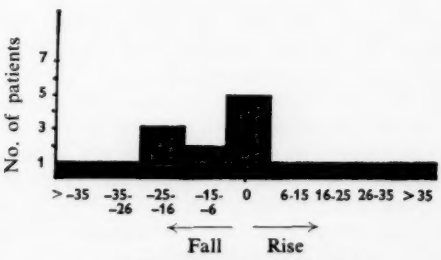


mm Hg change in systolic B.P.
Hypertensive patients.
Systolic B.P. 151 mm Hg or above.

Nitrous Oxide-Oxygen-Halothane.



mm Hg change in systolic B.P.
Normotensive patients.
Systolic B.P. 150 mm Hg or below.



mm Hg change in systolic B.P.
Hypertensive patients.
Systolic B.P. 151 mm Hg or above.

Resistant patients.

Both the supplementary agents helped to provide smoother anaesthesia in patients expected to be resistant, and halothane was very considerably superior to trichloroethylene in this respect. This is shown in table IV.

Respiratory depression.

There was no evidence of respiratory depression in any case in the series.

Oxygenation.

The use of either adjuvant permitted a significant increase in the amount of oxygen which could be added to the inspired gases, and this increase was more marked with halothane than with trichloroethylene. It was not possible to record the added oxygen percentage since this varied with requirements during each anaesthetic. It was notable that in the operations lasting more than 5 minutes it was possible in fit patients when using halothane, but not with the other techniques, to maintain anaesthesia with 20 per cent oxygen in the inspired mixture. In all cases oxygenation was kept to a maximum consistent with tranquil anaesthesia.

Gas flows and vapour concentrations.

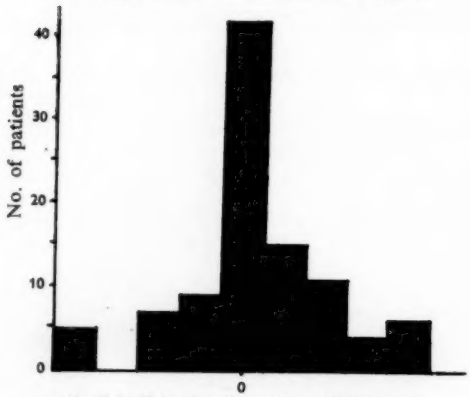
The flow of gases through the apparatus when used as described was found to lie between the limits of 36–46 litres per minute, with a mean of 40 litres/min. The average duration of halothane anaesthesia was 2.04 minutes, and the number of patients anaesthetized per hour varied up to a maximum of eight. It was found that under these conditions 10 ml of halothane sufficed for six anaesthetics. During the operating session the halothane in the vaporizer cooled and its level fell, both factors contributing to a reduction in the vapour concentration. When anaesthetics were given at short intervals this reduction was greatest because the halothane had not time to regain room temperature between cases.

Under the conditions described the vapour concentrations reached a maximum of 0.5 per cent v/v, falling to 0.25 per cent after 2 minutes continuous use. After five anaesthetics with inductions separated by intervals of 8–10 minutes the initial concentration was 0.35 per cent, falling to 0.1 per cent after 2 minutes.

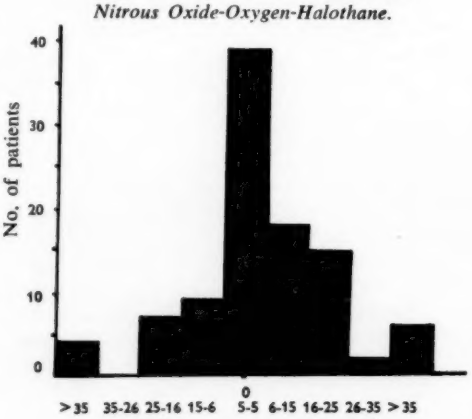
Higher concentrations and vaporizer settings were not used during the series, but the initial

TABLE II

Unsupplemented Nitrous Oxide-Oxygen.



Nitrous Oxide-Oxygen-Halothane.



Nitrous Oxide-Oxygen-Trichloroethylene.

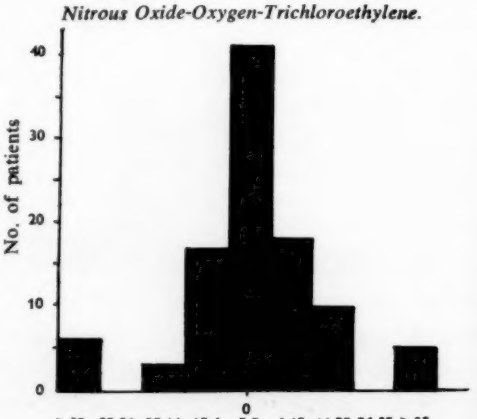
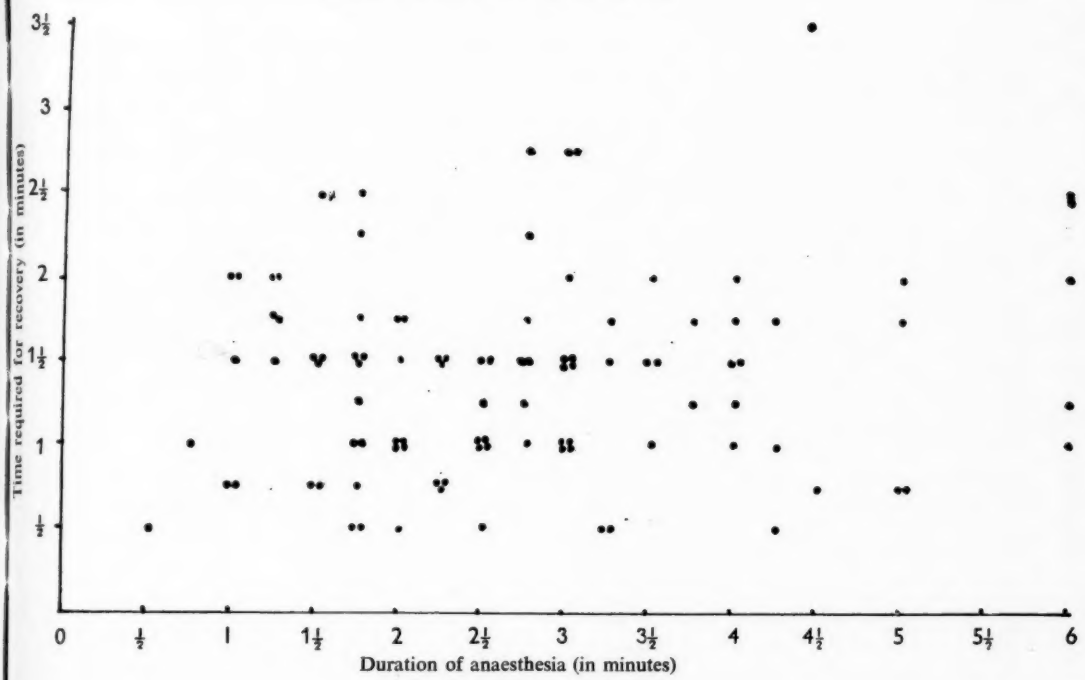


TABLE III

Unsupplemented Nitrous Oxide-Oxygen.



Nitrous Oxide-Oxygen-Halothane.

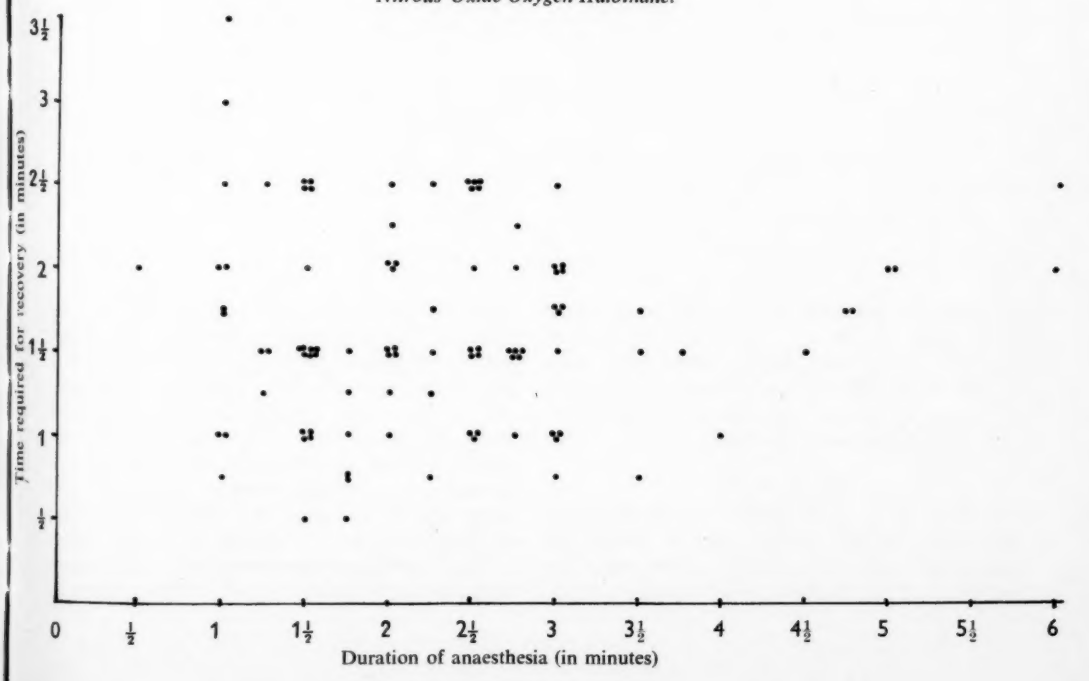


TABLE III—*continued*
Nitrous Oxide-Oxygen-Halothane.

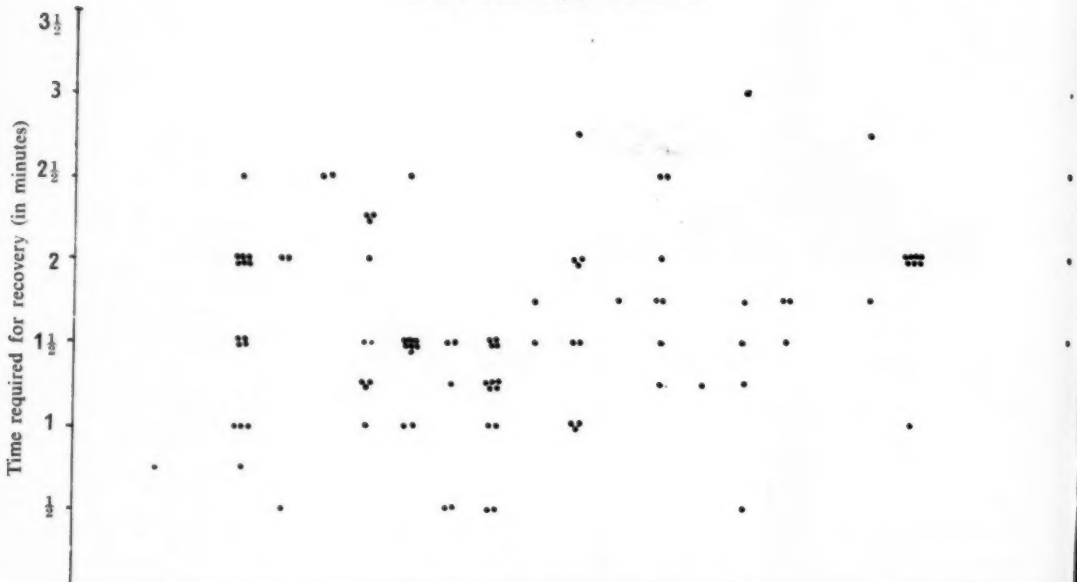


TABLE IV

Assessed as resistant		Anaesthesia		Assessed as "Good" but anaesthetic unsatisfactory
		Satisfactory	Unsatisfactory	
N_2O–O_2. alone	12	4	8	6
N_2O–O_2. halothane	13	13	0	3
N_2O–O_2. T.C.E.	13	9	4	3

concentration provided by the vaporizer in use at the ¾ mark was 0.85 per cent, and at the full position 1.05 per cent, both readings being with the bottle full (10 ml), and at room temperature.

Vapour concentrations were not measured when trichloroethylene was used.

CONCLUSIONS

Halothane is a useful additive to nitrous oxide anaesthesia in the dental chair. It permits an appreciable reduction, and in some cases the abolition of the hypoxia which usually accompanies the use of the gas in unpremedicated outpatients. This is probably of greatest value when anaesthetizing aged patients or those with pathology rendering them more than usually susceptible to the effects of hypoxia. The drug is of value in controlling the anaesthetic-resistant patient without undue hypoxia or delay in recovery, and it provides operating conditions and tranquillity of anaesthesia not attainable by other methods. Recovery is scarcely prolonged when compared with unsupplemented nitrous oxide, or when trichloroethylene is used. Patients, particu-

larly children, have slightly increased incidence of vomiting compared to unsupplemented nitrous oxide, but this is no greater than with trichloroethylene. No patient who had halothane developed cardiac arrhythmias, and the anticipated complications of bradycardia, hypotension and respiratory depression did not arise. One patient who received the drug developed symptoms which may have been epileptic in nature, but her condition at no time caused anxiety. The apparatus was simple and inexpensive, and when used as described the vapour concentrations were safe. Further work will be necessary to ensure that all similar inhalers produce concentrations of this order, and that there can be no possibility of a great increase in vapour strength when used differently; e.g. with very different gas flows, or with intermittent flow.

Premedication is unnecessary, a "sine qua non" of outpatient dental anaesthesia.

ACKNOWLEDGMENTS

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MODERN CONSIDERATIONS IN NEUROSURGICAL ANAESTHESIA

BY

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RECENT advances in anaesthesia have done much to add to the safety of the patient and to improve operating conditions for the surgeon. Particularly in the neurosurgical field, these advances have enabled the surgeon to embark on formidable procedures which previously carried a prohibitive mortality or were abandoned because of impossible operating conditions. In this paper it is proposed to discuss some of the problems arising in neurosurgical anaesthesia and to describe the techniques which we employ with particular reference to the use of controlled hypotension and hypothermia.

TYPE OF PATIENT

As in all branches of surgery, patients differ greatly in their pre-operative fitness for anaesthesia and surgery. The pre-operative level of consciousness may vary from normality to clouding of consciousness or semi-coma. These latter cases necessarily involve the minimal use of depressant agents. Of recent years hypophysectomy to stem the ravages of metastatic breast cancer has been increasingly performed, and these patients present a very poor risk group of cases. Many of them have impaired respiratory function from pulmonary metastases and pleural effusions. Anaemia is regularly present and careful positioning is necessary owing to the frequency of vertebral deposits. Vasomotor instability is common in these and many other patients who have been confined to bed for long periods and, if possible, pre-operative ambulation is carried out, particularly in cases likely to be dealt with in the sitting up position.

Prolonged pre-operative medication with barbiturates, analgesics or chlorpromazine will affect the patient's requirements. Resistance to thiopentone is rare (Dundee, 1956) and most patients become unconscious with relatively small induction doses. Patients with high intracranial pressures exhibit respiratory depression even with low dosages of thiopentone and pethidine. Finally, the blood pressure may be very labile in patients who have had prolonged pre-operative cortisone and care in the use of hypotensive agents is necessary.

REQUIREMENTS OF ANAESTHESIA

The basic requirements in neurosurgical anaesthesia have been frequently stressed. There should be smooth spontaneous respiration of adequate tidal volume through a perfect airway with a complete absence of coughing or straining either during induction or during the subsequent anaesthesia. Ballantine and Jackson (1954) have discussed the deleterious effects of either a rise in venous pressure or carbon dioxide retention and have shown how airway obstructions may occur even when using flexo-metallic tubes.

We regard adequate spontaneous respiration as the best method of keeping the venous pressure within normal limits although we are aware that in some centres controlled respiration with complete muscular paralysis is employed routinely. Valuable information may be gained from the movements of the reservoir bag and when frequent pulse and blood pressure observations are necessary in addition to the management of hypotension and/or hypothermia controlled respiration becomes impracticable. It must be admitted, however, that very occasionally a patient will not settle down to satisfactory spontaneous respiration and controlled respiration becomes necessary.

Carbon dioxide accumulation in the anaesthetic circuit is avoided by employing a Ruben "no rebreathing" valve with a high flow of gases and minimal deadspace. Any resistance to respiration is prevented by the use of the largest flexo-metallic tube which will pass with ease and the

endotracheal connection is pushed well down to the wire spiral and secured. The connection is firmly fixed to the face by strapping after ensuring that the tip of the tube lies approximately at the midpoint of the trachea. Undue flexion of the neck will tend to push the tube down the trachea while, particularly in infants, extension may cause it to spring out of the larynx. Inflatable cuffs may be slid on to these tubes (sizes 11 and 12) but we sometimes use a pharyngeal pack to ensure an airtight fit.

Coughing, straining or an expiratory "heave" must be avoided during induction and subsequent anaesthesia. This necessarily involves intubation under suxamethonium paralysis and thorough spraying of the larynx and trachea with topical analgesic solution. We use 4 per cent lignocaine and a Multicaine or Oxycaine spray to ensure analgesia to the level of the carina. Local analgesia of the air passages may not be complete before the effect of the suxamethonium has worn off and a further small dose of thiopentone (100 mg) may be necessary. Recently we have used halothane and a smooth resumption of spontaneous respiration is usually obtained.

CHOICE OF ANAESTHETIC

The choice of anaesthetic agent which will provide adequate respiration without the surgical stimulus evoking any response from the patient has presented some difficulty in the past. Anaesthesia is usually maintained by nitrous oxide and oxygen supplemented by inhalation or intravenous agents.

We regard trichloroethylene as unsuitable in prolonged procedures because of its tendency to cause tachypnoea and cardiac arrhythmias. Incremental doses of pethidine are frequently required in addition and these may have an unduly depressant effect on respiration and cause a rise in C.S.F. presure (Swerdlow, 1956).

Until recently we have used N_2O/O_2 (6:2) supplemented by small doses of thiopentone (2.5 per cent solution) and pethidine (1 per cent solution) intravenously. This usually provides a satisfactory anaesthetic technique but in some long procedures undesirably large total doses are given and some postoperative depression may ensue. Our indications for incremental doses depend entirely on the character of respiration. If breathing becomes too deep a small dose of thiopentone is usually necessary (100 mg 2.5 per cent solution) while if rapid respiration occurs (usually a response to surgical stimulation) then pethidine is given (10–20 mg). In operations on the posterior fossa involving manipulation of vital structures in the pons and medulla gross variations in respiratory rhythm may occur. These changes may be misinterpreted as indicative of lightening anaesthesia and the temptation to "seize the syringe" must be resisted.

During the last six months we have increasingly used halothane in neurosurgical cases and have been impressed by the good operating conditions provided. Increments of thiopentone or pethidine are usually unnecessary, although occasionally a small dose of the latter drug (10–20 mg) may be useful to check tachypnoea. Postoperative recovery of consciousness is rapid after the longest procedures with freedom from nausea and vomiting. We have not found a calibrated vaporizer essential and use the Trilene bottle with the plunger just above the surface, the lever barely "ON" and assess the amount of halothane required upon the patient's response and not on a percentage basis. A further advantage of halothane is the moderate hypotension produced. We assume that the relatively dry field in the presence of slight hypotension (20–30 mm Hg reduction) is due to vasodilatation and pooling in the dependent parts of the body in the head-up position. Halothane has proved particularly valuable in the management of infants and small children undergoing neurosurgical procedures.

REDUCTION OF HAEMORRHAGE

Apart from these purely anaesthetic considerations the anaesthetist may do much to help his surgical colleague by the reduction of haemorrhage during craniotomies, laminectomies, stellectomy, etc. Reduced bleeding is of great value in most neurosurgical procedures and is essential in operations involving the removal of angiomata, meningiomata, and the treatment of intracranial aneurysms.

Controlled hypotension is of no avail when bleeding is principally venous in origin and the prevention of a rise in venous pressure by cough-

ing, etc., has already been discussed. Undue rotation of the head must be avoided as compression or torsion of the jugular veins will also result in increased venous haemorrhage. During lumbar laminectomy in the prone position any compression of the inferior vena cava must be avoided as a rise in caval pressure is rapidly transmitted to the thin-walled epidural veins (Pearce, 1957).

Posture is commonly employed to reduce haemorrhage, the most extreme form being the adoption of the sitting position for posterior fossa explorations and cervical laminectomies. Although this position produces a relatively bloodless field it is not without its dangers. Air embolism is an ever present hazard and in the event of any circulatory collapse, the difficulties of getting the patient rapidly into the horizontal position are considerable. Any form of controlled hypotension in this position is hazardous although we have used halothane for posterior fossa craniotomies without experiencing undue fall in blood pressure.

Reduction in systolic pressure is usually carried out with trimetaphan (Arfonad 0.1 per cent or 0.05 per cent solution). Trimetaphan is used during most craniotomies provided absolute contra-indications to hypotension do not exist, and unless hypothermia is used in addition we do not allow the systolic pressure to fall below 80–85 mm Hg in the normotensive patient. This reading is at the level of the brachial cuff and the pressure at the operation site will be slightly lower in the head-up position (2 mm Hg drop for each 1 inch vertical height).

HYPOTHERMIA

Of recent years the value of moderate levels of hypothermia in neurosurgical operations has been increasingly utilized (Inglis and Turner, 1957; McBurrows and Dundee, 1956). We employ a surface cooling method using the Birmingham hypothermia unit which has been described in a previous publication (Inglis et al., 1954). We regard hypothermia as an essential part of the anaesthetic technique when controlled hypotension to levels below 80 mm Hg is adopted. This includes the majority of cases of angioma, meningioma, and aneurysms which may bleed profusely at normal levels and formerly often required a two-stage operation. Hypothermia is also indicated when major cerebral vessels are to be temporarily occluded. The use of hypothermia in nonvascular tumours in the region of the hypothalamus, diencephalon and brainstem has been described by Inglis and Turner (1957). There was formerly a high postoperative mortality in these cases from hyperpyrexia and coma probably due to hypothalamic anoxia and cerebral oedema. This has been greatly reduced since hypothermia has been routinely used. Recently we have used hypothermia for hypophysectomies and it is our impression that the postoperative course of these patients is smoother.

Our cooling technique involves the use of two tubulated blankets through which refrigerated or warmed ethylene glycol may be pumped. After induction of anaesthesia the patient is placed on the lower blanket on the operating table and covered with the second blanket, only the head extruding. Rectal and oesophageal leads are led out to a thermocouple and the desired degree of hypothermia is usually obtained by the time the vital operative period arrives. Cooling is usually rapid but in some obese patients or others who cool slowly it is facilitated by a small (20 mg) dose of promazine (Sparine). This drug lacks the tendency of chlorpromazine to cause tachycardia. A final temperature of approximately 30°C is aimed at and active cooling stopped when it is thought that a drift to this temperature will occur. At this temperature cardiac arrythmias or marked bradycardia rarely occur. Active cooling is stopped by turning off the circulation to the blankets and the fluid in the refrigerating tank either held at a low temperature or heated in readiness to rewarm the patient. Patients are returned to the ward at a temperature (oesophageal) of approximately 33–34°C, and no active measures to rewarm further are taken. If shivering occurs small intramuscular doses of promazine are given.

Halothane is now used routinely as the anaesthetic when hypothermia is to be employed. Cooling is rapid, presumably due to vasodilatation, and hypotension with trimetaphan frequently unnecessary. When hypotension is required the trimetaphan is diluted to 0.05 per cent solution and administered with caution. Under halothane anaesthesia it is seldom, if ever, necessary to use promazine to facilitate cooling.

SUMMARY

The authors have attempted to describe the main requirements of neurosurgical anaesthesia and have described the techniques which they have found reliable. It is felt that hypothermia is indicated in procedures when any hypotension below 80 mm Hg is undertaken or when the surgical procedure is in the region of the mid-brain or hypothalamus. Halothane has proved a useful addition to the anaesthetist's armamentarium in these cases.

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BOOK REVIEW

The British Encyclopaedia of Medical Practice. Editor in Chief: Lord Cohen of Birkenhead. Published by Butterworth & Co. (Publishers) Ltd., London.

Medical Progress: 1958. Pp. 341 + index. Price 37*s.* 6*d.*

Cumulative Supplement to the British Encyclopaedia of Medical Practice. Pp. 395. Price 37*s.* 6*d.*

Anaesthesia changes perhaps more rapidly than almost any other branch of medicine and the problem of keeping up to date is one which exercises the mind of all practitioners of this specialty. The 1958 "Medical Progress" volume of the *British Encyclopaedia of Medical Practice* offers a way of doing this. There are exhaustive and critical papers on many branches of medicine including a most valuable review of modern drugs such as the tetracyclines, the newest sulphonamides and the hypnotics methyprylone (Noludar) and glutethimide (Doriden) both of which may have a use as pre-operative sedatives.

There is an excellent critical review of recent developments in anaesthesia by Dr. Dundee of Belfast which should be read by every practising anaesthetist. We therefore heartily commend this volume.

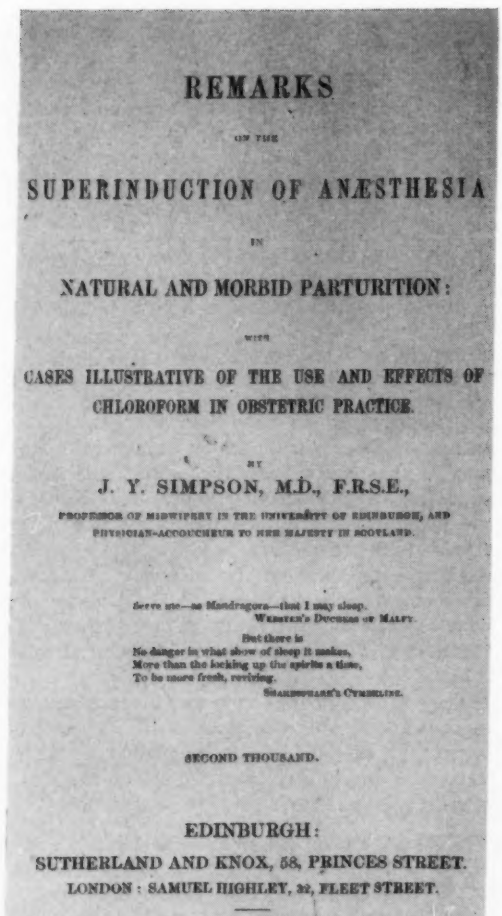
The accompanying cumulative supplement to the *British Encyclopaedia* is of less direct interest to anaesthetists. It maintains the high standard of previous volumes and will no doubt be of great value to those already possessing them.

A. R. Hunter

SUPERINDUCTION OF ANAESTHESIA IN NATURAL AND MORBID PARTURITION

BY

J. Y. SIMPSON



REMARKS

ON THE

SUPERINDUCTION OF ANÆSTHESIA

IN

NATURAL AND MORBID PARTURITION:

WITH

CASES ILLUSTRATIVE OF THE USE AND EFFECTS OF CHLOROFORM IN OBSTETRIC PRACTICE.

BY

J. Y. SIMPSON, M.D., F.R.S.E.,

PROFESSOR OF MIDWIFERY IN THE UNIVERSITY OF EDINBURGH, AND PHYSICIAN-ACCOUCHEUR TO HER MAJESTY IN SCOTLAND.

Give me—ay Mandragora—that I may sleep.
WEBSTER's DUCHESS OF MALFY.

But there is
No danger in what show of sleep it makes,
More than the locking up the spirits a time,
To be more fresh, reviving.
SHAKESPEARE's CYMBELINE.

SECOND THOUSAND.

EDINBURGH:
SUTHERLAND AND KNOX, 58, PRINCES STREET.
LONDON: SAMUEL HIGHLEY, 32, FLEET STREET.

MDCCCXLVIII.

Facsimile of the original title page.

Among the many improvements by which the operative part of medicine has, from time to time, been enriched, few or none have exerted a more potent, or a more beneficial influence over its advancement and progress than the introduction, in the 16th century, of the application of ligatures to arteries, with the object of arresting the hemorrhage attendant upon surgical wounds and operations. Previously to that time, surgeons had no other means of stemming the flow of blood—after amputation of the limbs for instance—than by scorching over the raw and bleeding wound with a red-hot iron, or by plunging it into boiling pitch, or by applying strong potential cauteries to its surface. With laudable efforts to diminish the fearful severities of their practice, they exerted their ingenuity in devising, as it were, refinements upon these necessitous cruelties. Thus Hildanus, the patriarch of German Surgery, amputated the limbs of his patients with red-hot knives, in order that he might divide the flesh and sear up the vessels at one and the same time. Upon all these practices, the great and happy suggestion of Ambrose Paré, viz. to shut up the bleeding vessels, by constricting or tying them with slender ligatures, was a vast and mighty improvement. It at once made the arrestment of hemorrhage in operations far more simple, more certain, and more secure. It saved immeasurably the sufferings of the patients, while it added immeasurably to their safety. But the practice was new, and an innovation; and consequently, like all other innovations in medical practice, it was, at first and for long, bitterly decried and denounced. The College of Physicians of Paris attacked Paré for his proposed new practice: they attempted, by the authority of the French Parliament, to suppress the publication and dissemination of his

[1] Read to the Medico-Chirurgical Society of Edinburgh, at their meeting on the 1st December 1847.

observations: and, for nearly a long century afterwards, some of the Hospital Surgeons of Paris continued, with the characteristic obstinacy of the profession, to prefer cauterizing bleeding arteries "with *all* the ancients," rather than simply tie them "after the manner of a few ignorant and presumptuous moderns."[1] "Without" (writes the late Mr John Bell)—"without reading the books of these old surgeons, it is not possible to imagine the horrors of the cautery, nor how much reason Paré had for upbraiding the surgeons of his own time with their cruelties. . . . The horrors of the patient, and his ungovernable cries, the hurry of the operators and assistants, the sparkling of the (heated) irons, and the hissing of the blood against them, *must* have made terrible scenes; and surgery *must*, in those days, have been a horrid trade."[2]

The sentiments which Mr Bell here expresses are those with which the human mind often *looks back* upon our opinions and practices, when these opinions and practices are past and gone, and have become mere matters of history. In the above, as in many other instances, we never become fully awakened to the cruelty and enormity of some of our established doctrines and doings, until, from time to time, an advance is made in civilisation or science, and we find that this or that doctrine and practice, with all its attendant sufferings and inhumanities, was in reality utterly unnecessary, and utterly uncalled for.[3] In general, however, long years elapse before this new aspect of matters is duly seen; or, at least, duly acknowledged. While the practices themselves are in full operation, the mind, enthralled by education and habit, cannot be easily made to view them in their true character; and when, in the progress of the march of knowledge and science, their propriety and perpetuation come at last to be challenged and contested, human passions and prejudices ever (as in the above instance of cauterization) rise up to argue for, and insist upon, the continuance and safety of the past, and the total impolicy and high peril of any attempted alteration. But time passes on, and brings with it, sometimes abruptly—generally almost imperceptibly—a perfect change of doctrine and practice. Any surgeon who, in the days of Paré, dared to arrest the hemorrhages from his amputation wounds, by applying ligatures *instead* of red-hot irons, would have been denounced by his compeers. Any surgeon, on the contrary, who now, at this present day, dared to arrest the hemorrhages from his amputation wounds, by applying to the bleeding vessels, not ligatures but red-hot irons, would as certainly be denounced by his compeers, and his talents, as well as his humanity, would be strongly challenged. We look back with sorrow upon the pitiless practices in that respect of the contemporaries and opponents of Paré. In the course of years our successors in the profession will, I most sincerely believe, look back with similar feelings upon the alleged "insignificance," and "propriety," and "desirability" of pain in surgical operations, as maintained by many members of the profession

[1] All writers on surgical history give more or less full details upon this opposition to the practice of Paré. Thus, for example, Professor Cooper observes, "By many surgeons, however, the tying of arteries continued to be deemed too troublesome, and hence they persisted in the barbarous use of the actual cautery; of this number were Pigrai, F. Plazzoni, and P. M. Rossi. Nay, so difficult was it to eradicate the blind attachment shown to the ancients, that Theodorus Baronius, a professor at Cremona, publicly declared, in 1609, that he would rather err with Galen than follow the advice of any other person. . . . I shall not here expatiate upon the ill-treatment which Paré experienced from the base and ignorant Gourmelin, president of the Parisian college of physicians; nor upon the slowness and reluctance with which the generality of surgeons renounced the cautery for the ligature. . . . Almost 100 years after Paré, a button of vitriol was ordinarily employed in the Hotel Dieu at Paris for the stoppage of hemorrhage after amputations; Dionis was the first French surgeon who taught and recommended Paré's method. This happened towards the close of the 17th century, while Paré lived towards the end of the 16th."—*Cooper's Dictionary of Practical Surgery*, 7th Edit. pp. 46, 47. See also *Sprengel's Histoire de Médecine*, Vol. III. p. 315; *Bell's Surgery*, Vol. I. p. 226, &c.

[2] Principles of Surgery, Vol. I. p. 212.

[3] Witness, for example,—(as compared with the *past* opinions of those who practised them)—our *present* opinions regarding the burning, by our Druidical forefathers, of whole wickerfuls of living human beings, and in the name of religion; or, in times nearer our own—in Christian times—the application of the fire and fagot by man to man, still under the plea of religion; or the use of the rack and torture; the incremation in the sixteenth and seventeenth centuries of many poor wretches for the alleged crime of witchcraft; the altered existing ideas regarding the required frequency of capital punishments, and the whole question regarding their policy; the recent rapid and complete change of doctrine regarding the horrors and inhumanity of slavery; the changes in practice regarding insanity from what it was in the last century, when chains and a dungeon were the portion of every poor lunatic; &c. &c.

at the present day; and they will equally marvel at the idea of men—of humane men—complacently confessing and upholding, that they prefer operating upon their patients in a waking instead of an anaesthetic state; and the fearful agonies which they thus inflict—the agonies of the surgeon's knife—should be endured rather than avoided—quietly and decorously submitted to, and not attempted to be eschewed. I have elsewhere discussed,[1] at some length, the strange opinions and practices of some modern surgeons, upon this alleged propriety and necessity of pain in surgical practice and surgical operations. On the present occasion, my object is to offer some remarks regarding the pains attendant upon parturition, and the propriety of alleviating and annulling the sufferings of our patients in obstetrical practice and obstetrical operations. But let me first adduce some evidence of *their* intensity and amount.

"The distress and pain (observes Dr Denham[2]) which women often endure while they are struggling through a difficult labour are *beyond* all description, and seem to be more than human nature would be able to bear under any other circumstances." But even the amount of agony endured in most cases of *natural* parturition, is abundantly severe.[3] Viewed apart, and in an isolated light, the total sum of actual pain attendant upon common labour is as great, if not greater, than that attendant upon most surgical operations. It is, I believe, education and custom, and perhaps the idea of its inevitable necessity, which have made the profession in general look upon the degree of maternal pain and physical suffering accompanying natural parturition, as less deserving of consideration than in reality it is. These circumstances have, in a great measure, blinded us as to its actual amount, and intensity, and importance. For it was, no doubt with perfect truth, remarked by an author[4] who wrote three hundred years ago, "Mulier, in partu, maximos et fere intolerabiles sustinet dolores."

Some living authors—without any view to such a question as the possibility of avoiding it—in fact, with a view only to the accurate painting of nature, have described to us in forcible language the degree of suffering attendant upon the last stages of the process of common parturition. "The pulse (says Dr Merriman) gradually increases in quickness and force; the skin grows hot; the face becomes intensely red; drops of sweat stand upon the forehead; and a perspiration, sometimes profuse, breaks out all over the body; frequently violent tremblings accompany the last pain, and at the moment that the head passes into the world, the extremity of suffering seems to be beyond endurance."[5] Or, let us take the picture of the sufferings of the mother in the last part of natural labour, as portrayed by one who is universally reputed by the obstetric profession as the most faithful of living observers—Professor Naegele of Heidelberg—"The pains (he observes) of this stage are still more severe, painful, and enduring; return after a short interval, and take a far greater effect upon the patient than those of the previous stage. Their severity increases so much the more from the additional suffering arising from the continually increasing distension of the external parts. They convulse the whole frame, and have hence been called the *dolores conquassantes*. The bearing down becomes more continued, and there is not unfrequently vomiting. The patient quivers and trembles all over. Her face is flushed, and, with the rest of the body, is bathed in perspiration. Her looks are staring and wild; the features alter so much that they can scarcely be recognised. Her impatience rises to its maximum with loud crying and wailing, and frequently expressions which, even with sensible, high-principled women, border close upon insanity. Every thing denotes the violent manner in which both body and mind are affected."[6] "This (observes Dr Rigby) is the moment of greatest pain, and the patient is frequently quite wild and frantic with suffering; it approaches to a species of insanity, and shows itself in the most quiet and gentle dispositions. The laws in Germany have made great

[1] See Monthly Journal of Medical Science for September 1847, Pp. 156–166, "On the Allegation of the Prevention of Pain in Surgical Cases being Unnecessary and Improper."

[2] Introduction to Midwifery. 5th edition, p. 377.

[3] Cases undoubtedly ever and anon occur, in which the mother suffers comparatively little or no pain; but these are exceptions, rare exceptions, to a general rule.

[4] Hieronymus Mercurialis, in Spachius Gynaecia, p. 233.

[5] Synopsis of Parturition, p. 15.

[6] Lehrbuch der Geburtshulfe, p. 104. See British and Foreign Medical Review, vol. xix. p. 64.

allowances for any act of violence committed during these moments of frenzy, and wisely and mercifully consider that the patient at the time was labouring under a species of temporary insanity. Even the act of child murder, when satisfactorily proved to have taken place at this moment, is treated with considerable leniency. This state of mind is sometimes manifested in a slighter degree by actions and words so contrary to the general habit and nature of the patient, as to prove that she could not have been under the proper control of her reason at the moment. It is a question how far this state of mind may arise from intense suffering, or how far the circulation of the brain may be affected by the pressure which is exerted upon the abdominal viscera."[1]

Such is the description of the amount of pain and agony endured in natural parturition, given by some of our best and most esteemed authorities in obstetric literature.

Is it right for the physician to interfere with these fearful sufferings and agonies in order to save and shield his patients from the endurance of them? Is it proper for him to exercise the skill of his art so as to moderate and remove these "almost intolerable pains (*fere intolerabiles dolores?*") Would it be fit and meet in him to use human means to assuage the pangs and anguish attendant upon the process of parturition in the human mother?

These questions, and questions like these, I have often during the currency of the present year, heard complacently put by medical men,—men, too, whose opinions and actions in other matters, and in other respects, were fully and truly actuated by that great principle of emotion which both impels us to feel sympathy at the sight of suffering in any fellow creature,[2] and at the same time imparts to us delight and gratification in the exercise of any power by which we can mitigate and alleviate that suffering. Such questions, I repeat, are seriously asked by physicians and surgeons, the professed object of whose whole science and art is the relief of human disease and human suffering. They are questions propounded with all imaginable gravity and seriousness by individuals who (in a mere abstract point of view) would, no doubt, strongly object to being considered as anxious to patronize and abet human misery, or traffic in the perpetuation of human pain. Nay, probably, at the date at which I write, there is not one in twenty—perhaps not one in a hundred—of the physicians and surgeons of Great Britain who have, as yet, thought seriously upon the propriety of alleviating and annulling the tortures attendant on human parturition; or who have acknowledged to their own minds the propriety of their bestirring themselves so as to be able, in the exercise of their profession, to secure for their patients an immunity from the throes and agonies of childbirth.

Perhaps, as an apology for their indolence and apathy, some may be ready to argue, that the pain and suffering attendant on parturition is not dangerous and destructive in its results, however agonizing and distressing it may be to the patient during its continuance. But the argument is fundamentally unsound. All pain is *per se*, and especially when in excess, destructive and even ultimately fatal in its action and effects. "It exhausts (says Mr Travers) the principle of life."[3] "It exhausts (says Mr Burns of Glasgow) both the system and the part."[4] "Mere pain (observed the late Dr Gooch) *can* destroy life."[5] And the great pain accompanying human parturition is no exception to this general pathological law. For, in fact, the maternal mortality attendant upon parturition, regularly increases in a ratio progressive with the increased duration of the woman's sufferings. The statistical data published by Dr Collins, in his Report of the Dublin Lying-in Hospital, affords ample proof of this general principle. According to calculations which I some time ago made from Dr Collins' data, I found that while in the women delivered in the Dublin Hospital, and whose sufferings were terminated within 2 hours, only 1 in 320 of the mothers died; where the labour varied in duration from 2 to 6 hours, 1 in 145 of the mothers died; in those in whom it continued from 7 to 12 hours, 1 in 80 died; where it endured for 12 to 24 hours, 1 in 26 died; where it lasted from 24 to 36 hours, 1

[1] System of Midwifery, p. 103.

[2] "Inditus est, ab ipsa Natura, homini, *misericordiæ* affectus nobilis et excellens." Bacon—"De Augmentis Scient.," Lib. viii. cap. ii.

[3] Inquiry concerning Constitutional Irritation, vol. i, p. 76.

[4] Principles of Surgery, vol. i. p. 502.

[5] Dr. Merriman's Synopsis of Parturition, p. 239.

in 17 died; and out of all those whose parturient sufferings were prolonged beyond 36 hours, 1 in every 6 perished.

Again, some may possibly be inclined to reason, that any means by which we could produce a state of anæsthesia or insensibility to the physical pains of labour, must, of necessity, be of such a character as to add to the perils and dangers of the patient. I believe this argument to be as futile and untenable as the one that I have just noticed. Indeed, judging from analogy, and from what is the fact in surgery, I believe that, as a counteraction to the morbific influence of pain, the state of artificial anæsthesia does not only imply a saving of human suffering, but a saving also of human life. Out of above 300 cases of the larger amputations performed during the current year, upon patients in an etherized or anæsthetic state, and which I have collated from different hospitals in Great Britain, Ireland, and France, a smaller proportion died than formerly used to perish in the same hospitals under the same operations without etherization. I shall take one of these amputations as an illustration of the whole—and that one the most severe of all—viz. amputation of the thigh. Malgaigne (1842) showed, that under amputations of the thigh, in the hospitals of Paris, 62 in every 100 died; in Edinburgh, the mortality from this operation, in the only years during which the hospital reports were published (1839–42), was 50 in every hundred; Mr Phillips of London (1844), found the average mortality 40 in 100; Dr Lawrie at Glasgow (1839), found it also in the hospitals of that city to be 40 in 100.[1] I have notes of 135 cases in which this same operation has been performed in hospital practice upon patients in an etherized state. Out of these 135 cases 33 died, or only 24 in 100. Hence I repeat, that the condition of anæsthesia not only preserves the patient in surgical practice from agony and torture, but actually preserves him too from the chances of danger and death. And I firmly believe, that the superinduction of anæsthesia in obstetric practice will yet be found to diminish and remove also, in some degree, the perils as well as the pains of labour.

In an essay which I wrote in February last, "On the Employment of the Inhalation of Sulphuric Ether in the Practice of Midwifery," (*Monthly Journal of Medical Science* for March 1847, p. 728), I offered some remarks on its application to cases of common as well as of morbid parturition, and took occasion to observe, "The question which I have been repeatedly asked is this—Will we ever be 'justified' in using the vapour of ether to assuage the pains of natural labour? Now, if experience betimes goes fully to prove to us the safety with which ether may, under proper precautions and management, be employed in the course of parturition, then, looking to the facts of the case, and considering the actual amount of pain usually endured, I believe that the question will require to be quite changed in its character. For, instead of determining in relation to it whether we shall be 'justified' in using this agent under the circumstances named, it will become, on the other hand, necessary to determine whether on any grounds, moral or medical, a professional man could deem himself 'justified' in withholding, and *not* using any such safe means (as we at present pre-suppose this to be), provided he had the power by it of assuaging the pangs and anguish of the last stage

[1] The following table exhibits the actual number of the cases of amputation of the thigh referred to in the text, with their respective results:—

MORTALITY ACCOMPANYING AMPUTATION OF THE THIGH.

Name of Reporter.	Number of Cases.	Number of Deaths.	Per Centage of Deaths.
Malgaigne—Paris,.....	201	126	62 in 100
Peacock—Edinburgh,.....	43	21	50 in 100
Phillips' Collection of Cases,...	660	263	40 in 100
Lawrie—Glasgow,.....	184	73	40 in 100
Total,.....	1088	483	44 in 100
Upon Patients in an Anæsthetic state,.....	135	33	24 in 100

of natural labour, and thus counteracting what Velpeau describes as 'as those piercing cries, that agitation so lively, those excessive efforts, those inexpressible agonies, and those pains apparently intolerable,'[1] which accompany the termination of natural parturition in the human mother."

Since the latter part of January, I have employed etherization, with few and rare exceptions, in every case of labour which has been under my care. And the results, as I have already elsewhere stated, have been, indeed, most happy and gratifying. I never had the pleasure of watching over a series of more perfect or more rapid recoveries; nor have I once witnessed any disagreeable result to either mother or child. I have kept up the anæsthetic state during periods varying from a few minutes to three, four, five, and six hours. I do not remember a single patient to have taken it who has not afterwards declared her sincere gratitude for its employment, and her indubitable determination to have recourse again to similar means under similar circumstances. All who happened to have formerly entertained any dread respecting the inhalation, or its effects, have afterwards looked back, both amazed at, and amused with, their previous absurd fears and groundless terrors. Most, indeed, have subsequently set out, like zealous missionaries, to persuade other friends to avail themselves of the same measure of relief in their hour of trial and travail; and a number of my most esteemed professional brethren in Edinburgh have adopted it with success, and results equal to my own. All of us, I most sincerely believe, are called upon to employ it by every principle of true humanity, as well as by every principle of true religion.[2] Medical men may oppose for a time the superinduction of anæsthesia in parturition, but they will oppose it in vain; for certainly our patients themselves will force the use of it upon the profession. The whole question is, even now, one merely of time. It is not—Shall the practice come to be generally adopted? but, When shall it come to be generally adopted? Of course, it will meet from various quarters with all due and determinate opposition. Medical men will, no doubt, earnestly argue that their established medical opinions and medical practices should not be harshly interfered with by any violent innovations of doctrine regarding the non-necessity and non-propriety of maternal suffering. They will insist on mothers continuing to endure, in all their primitive intensity, all the agonies of childbirth, as a proper sacrifice to the conservatism of the doctrine of the desirability of pain. They will perhaps attempt to frighten their patients into the medical propriety of this sacrifice of their feelings;[3] and some may be found who

[1] Traité des Accouchemens, Vol. I. p. 449. "Ces cris percans, cette agitation si vive, ces efforts excessifs, ces angoisses inexprimables, ces douleurs qui parassaient intolerables," &c.

[2] See "Answer to the Religious Objections urged against the employment of Anæsthetic Agents in Midwifery and Surgery."

[3] We can all recollect the many absurd stories of apocryphal disasters and deaths that the opponents of etherization busily and anxiously reported towards the commencement of the present year, as having occurred from the employment of ether-inhalation in surgery. Dr Forbes, in his excellent article on etherization, in treating of these unscrupulous and disreputable pieces of professional gossip, observes—"One day we had death from asphyxia; another from coma; another from hemoptysis; some from convulsions; a few from pneumonia; and one or two from actual incremation, or explosion, through the accidental firing of the ethereal vapour within the air passages. We have not had time to investigate all these terrible cases; but we may state that we traced *the one* which seemed the *best* authenticated—that from hemoptysis—from its full-blown majesty in after-dinner gossip, to its humble source in the hospital. And this was the case, as the man himself detailed it to us:—A day or two after a successful operation for hernia, under etherization, the man pricked his gums while picking his teeth with a pin; and it was the product of *this* operation, not of the ether, seen in the spitting-pot by the patient's bedside, that was bruited about town, as of itself sufficient to settle the question in all future time!—(*British and Foreign Medical Review*, No. XLVI. April 1847, p. 564).—When first employing etherization in midwifery, I met with no small number of similar strange tales and accusations. For example, in February last, a patient who happened to be severely frightened had, in consequence, a premature labour. The child presented preternaturally; and died a day or two after birth. The mother was attacked with phlegmasia dolens, and made a very long and protracted recovery. Various kind friends, anxious about the results of etherization in midwifery, warned me of the professional odium which this case was bringing upon the new practice, and of the strong argument which it was affording to others against the safety of ether-inhalation in obstetrics. I was repeatedly and credibly told that ladies had informed their physicians, that the quantity used was *so* great that they had felt the odour of it perfectly oppressive when calling, even days afterwards, at the house of my patient. The answer to all this was sufficiently simple. The danger of death to the child from its prematurity and preternatural presentation appeared to be from the first so imminent, that I did not choose to peril the character of the new practice by following it in this case. The ether had not only not been used:

will unscrupulously ascribe to the new agency any misadventures, from any causes whatever, that may happen to occur in practice. But husbands will scarcely permit the sufferings of their wives to be perpetuated merely in order that the tranquillity of this or that medical dogma be not rudely disturbed. Women themselves will betimes rebel against enduring the usual tortures and miseries of childbirth, merely to subserve the caprice of their medical attendants. And I more than doubt if any physician is really justified, on any grounds, medical or moral, in deliberately desiring and asking his patients to shriek and writhe on in their agonies for a few months—or a few years longer—in order that, by doing so, they may defer to his professional apathy, or pander to his professional prejudices.

Two agents have the power of producing anæsthesia during labour, viz. the inhalation of sulphuric ether, and the inhalation of chloroform. With most, if not all, of my professional brethren, I believe that the latter agent possesses various important advantages over the former, particularly in obstetric practice; and that, in particular, it is far more portable; more manageable and powerful; more agreeable to inhale; is less exciting than ether; and gives us far greater control and command over the superinduction of the anæsthetic state. In the remaining part of these observations I shall detail briefly some instances illustrative of its effects and utility in the production of anæsthesia in cases of natural and morbid parturition.

CASE I.—The patient to whom it was first exhibited had been previously delivered in the country by craniotomy after a very long labour. Her second confinement took place a fortnight before the full time. Chloroform was begun to be inhaled when the os uteri was becoming well expanded, and the pains very severe. In twenty-five minutes the child was born. The crying of the infant did not rouse the mother, nor did she awake till after the placenta was removed. She was then perfectly unaware that her child was born. She stated her sensations to be those of awaking from "a very comfortable sleep." It was, for a time, a matter of no small difficulty to persuade her that the labour was over, and that the living child presented to her was her own.

CASE II.—I exhibited it, with Mr Carmichael, to a patient who had, at her preceding confinement, been in severe labour for twenty hours—followed by flooding. She began the inhalation when the dilatation of the os uteri was half completed. The child was born in fifty minutes afterwards. She was kept under its influence for a quarter of an hour longer, till the placenta was removed, and the binder, body and bed-clothes, all adjusted. On awakening, she declared she had been sleeping refreshingly; and was quite unconscious that the child was born, till she suddenly heard it squalling at its first toilet in the next room. No flooding. An hour afterwards, she declared she felt perfectly unfatigued, and not as if she had borne a child at all.

CASE III.—Patient unmarried. A first labour. Twins. The first child presented by the pelvis, the second with the hand and head. The chloroform was exhibited when the os uteri was nearly fully dilated. The passages speedily became greatly relaxed (as has happened in other cases placed under its full influence); and in a few pains the first child was born, assisted by some traction. I broke the membranes of the second, pushed up the hand, and secured the more complete presentation of the head. Three pains expelled the child. The mother was then bound up; her clothes were changed; and she was lifted into another bed. During all this time she slept on soundly, and for a full hour afterwards; the chloroform acting in this, as in other cases of its prolonged employment, as a soporific. The patient recollected nothing from the time of the first inhalations; and was in no small degree distressed when not one—but two—living children were brought by the nurse to her. Dr Christison accompanied me to this case.

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but not a drop of it had ever been in the house.—One of my patients was zealously attempted, some months ago, to be persuaded against the "horrors of ether," on the strong and round assertion, that some dozen ladies or more in Dublin, upon whom the practice had been tried, had indubitably perished from the effects of it. Unfortunately for the veracity of this statement, ether-inhalation had never once been used, or attempted to be used in obstetric practice in Dublin, up to that date, or for a long time afterwards. Indeed, the first case in which ether was employed in midwifery in Dublin only occurred this week (28th Nov.); as I am informed in a letter of that date, which I have just received regarding it, from Dr Tyler.

CASE IV.—Primipara of full habit. When the first examination was made, the passages were rigid, and the os uteri difficult to reach. Between six and seven hours after labour began, the patient, who was complaining much, was apathized with the chloroform. In about two hours afterwards, the os uteri was fully dilated, and in four hours and a half after the inhalation was begun, a large child was expelled. The placenta was removed, and the patient bound up and dressed before she was allowed to awake. This patient required an unusual quantity of chloroform; and Dr Williamson, who remained beside her, states to me in his notes of the case, "the handkerchief was moistened often in order to keep up the soporific effect. On one occasion, I allowed her to emerge from this state for a short time; but on the accession of the first pain she called out so for the chloroform, that it was necessary to pacify her by giving her some immediately. In all, four ounces of chloroform were used." Like the others, she was quite unconscious of what had gone on during her anæsthetic state; and awoke altogether unaware that her child was born.

CASE V.—Second labour. This patient, after being several hours in labour, was brought to the Maternity Hospital. I saw her some time afterwards, and found the first stage protracted by the right side of the cervix uteri being thick, œdematous, and undilatable. The inhalation of chloroform was begun, and the first stage was terminated in about a couple of hours. Two or three pains drove the child through the pelvic canal, and completed the second stage. Fifteen minutes in all elapsed from the termination of the first to the termination of the third stage, or the expulsion of the placenta. The patient was dressed and removed into dry bed, where she slept on for a short time before awakening, and being conscious of her delivery.

CASE VI.—Second labour. The patient, a person of small form and delicate constitution; bore her first child prematurely at the seventh month. After being six hours in labour, the os uteri was fully expanded, and the head well down in the pelvic cavity. For two hours subsequently, it remained fixed in nearly the same position, and scarcely if at all advanced, although the pains were very distressing, and the patient becoming faint and exhausted. She entertained some mistaken religious feelings against ether or chloroform, which had made her object to the earlier use of the latter; but I now placed her under its influence. She lay as usual like a person soundly asleep under it, and I was now able, without any suffering on her part, to increase the intensity and force of each recurring pain, by exciting the uterus and abdominal muscles through pressure on the lower part of the vagina and perineum. The child was expelled in about fifteen minutes after the inhalation was commenced. In a few minutes she awoke to ask if it was really possible that her child had been born; and was overjoyed to be told that it was so. I had the conviction that in this case the forceps would in all probability have been ultimately required, perhaps hours subsequently, provided I had not been able to have interfered in the way mentioned. I might, it is true, have followed the same proceeding though the patient was not in an anæsthetic state, but I could not have done so without inflicting great misery and agony upon her, and meeting with great resistance.

CASE VII.—A third labour. The patient had been twice before confined of dead premature children; once of twins, under the care of Mr Stone of London; the second time of a single child, under my own charge. The liquor amnii began to escape about one o'clock A.M., but no pains followed for some time. I saw her between three and four, with the pains commencing, and the os uteri beginning to dilate. In two hours afterwards the first stage was well advanced, and, the pains becoming severe, she had the chloroform exhibited to her, and slept soundly under its influence. In twenty minutes the child was born, and cried very loudly without rousing the mother. In about twelve or fifteen minutes more she awoke, as the application of the binder was going on, and immediately demanded if her child was really born and alive, as she thought she had some recollection of hearing the nurse say so. She was rejoiced beyond measure on her son being brought in and presented to her.

CASE VIII.—Fourth labour. The patient had born three dead children prematurely, about the sixth and seventh months of utero-gestation. Dur-

ing her present pregnancy I placed her under strict rules and discipline; and she used, from an early period, small doses of chlorate of potass several times a-day. She carried her child to the full time. Labour came on about one o'clock A.M. The membranes broke at eight A.M., when the os uteri was still very slightly open. It had made very little progress till ten o'clock, when Dr Keith exhibited the chloroform to her. The pains continued very strong and regular, the passages relaxed, and at half-past eleven she was delivered of a large living child. The placenta came away immediately; and she was bound up, and her soiled clothes removed, before she awoke. She remembered nothing whatever that had occurred after she began to inhale the chloroform till the period of her awaking.

The preceding instances afford, perhaps, a sufficient number of examples of the use of chloroform in natural labour. In these and in all others which I have seen, or that have been reported to me, the immediate effects of the chloroform have been delightful. The mothers, instead of crying and suffering under the strong agonies and throes of labour, have lain in a state of quiet, placid slumber, made more or less deep at the will of the medical attendant, and, if disturbed at all, disturbed only unconsciously from time to time by the recurring uterine contractions producing some reflex or automatic movements on the part of the patient—like those of a person moving under any irritation of the surface, or from the touch of another, though still in a state of sleep. Nor have the ultimate consequences and results been less happy. No difficulties have been met with in the third stage; and the uterus has contracted perfectly after delivery. I never saw mothers recover more satisfactorily or rapidly,—or children that looked more viable. And the practice is not a great blessing to the patient merely; it is a great boon also to the practitioner. For whilst it relieves the former from the dread and endurance of agony and pain, it both relieves the latter from the disagreeable necessity of witnessing such agony and pain in a fellow-creature, and imparts to him the proud power of being able to cancel and remove pangs and torture that would otherwise be inevitable. It transforms a work of physical anguish into one of painless muscular effort; and changes into a scene of sleep and comparative repose, that anxious hour of female existence, which has ever been proverbially cited as the hour of the greatest of mortal suffering.

The effects of the superinduction of anæsthesia in parturition are, if possible, still more marked and beneficial in cases of morbid labour and operative delivery. In proof of its influence in this respect, I shall cite some examples of its employment in cases of turning, of the application of the forceps, and of embryulsio.

CASE IX.—Fourth labour. The mother deformed, and the conjugate diameter of the brim of the pelvis contracted from the projection inwards and forwards of the promontory of the sacrum. Her first child was delivered by embryulsio; the second by the long forceps; the third was small, and passed without artificial assistance. On the present occasion, after suffering slight pains during the whole night, labour set in with greater severity towards morning. After being in strong labour for some hours, she was seen first by Mr Figg, and afterwards by Dr Peddie, her ordinary medical attendant. I was called to her about four o'clock P.M. The pains were then enormously powerful and straining, imparting to the mind the dread of the uterus rupturing under their influence; but the head of the child was still altogether above the brim, and only an œdematous ridge of the scalp pressed through the superior and contracted pelvic opening. The passages had become heated, the mother's pulse raised, &c., and Dr Peddie had tried two different pairs of long forceps. After I arrived he applied, with great skill, another pair of long forceps which I had with me; but it was found impossible to move the head in the least degree forwards. The urgency and power of the uterine contractions, the immobility of the head upon the brim of a deformed pelvis, and the state of the patient and of the parts, all showed the necessity of relief being obtained by artificial delivery. In her first labour I had assisted Dr Peddie in delivering her under similar circumstances by perforation of the head. But here the child's heart was heard distinctly with the stethescope, and he at once agreed to my proposition, that I should try to deliver her by turning the infant,—compressing and indenting the flexible skull of the fœtus, instead of per-

forating it, and thus affording (as I have for some time past taught and believed) some chance of life to the child, and more chance of safety to the mother. The patient was placed under the influence of chloroform still more deeply than when the forceps were used, in order, if possible, entirely to arrest the uterine contractions. I passed up my hand into the uterus, seized a knee, and easily turned the infant; but very great exertion and pulling was required to extract the child's head through the distorted brim. At last it passed, much compressed and elongated. The child was still-born, but, by applying the usual restorative means, it speedily began to breathe and cry. The child continues well, and the mother has made a rapid recovery.

CASE X.—In the Maternity Hospital; first child. Labour began at ten P.M. (21st Nov.). I was desired to see her at six A.M. (22d.) The os uteri was well dilated, but it was evident that the pelvic canal was contracted throughout, and the head was passing with unusual difficulty through the brim. The patient was complaining much of her sufferings. It was clear that it would be a very tedious and probably at last an instrumental case, and one therefore calculated to test the length of time during which chloroform might be used. She began to inhale it at a quarter past six A.M., and was kept under its influence till a quarter past seven P.M., the date of her delivery; thirteen hours in all. From the time it was begun to the time delivery was completed, her cries and complaints ceased, and she slept soundly on throughout the day. The bladder required to be emptied several times with the catheter. The head passed the os uteri at ten A.M.; and, during the day, gradually descended through the pelvis. At seven P.M. I at last deemed it proper to deliver her by the forceps; the head, which was now elongated and œdematous, having by that time rested for some hours against the contracted pelvic outlet with little or no evidence of advancement, the bones of the fœtal cranium overlapping each other, and the fœtal heart becoming less strong and distinct in its pulsations. A warm bath, irritation of the chest, &c., were necessary to excite full and perfect respiration in the infant. Whilst we were all busied with the infant the mother lost some blood; but the placenta was immediately removed, and the uterus contracted perfectly. On afterwards measuring the quantity of blood lost, it was calculated to amount to 15 or 18 ounces. The mother's clothes were changed; she was bound up and removed to a dry bed before she awoke. She had at first no idea that the child was born, and was in no respect conscious of being delivered. In fact she had been "sleeping," according to her own account, from the time she had begun the inhalation, and only thought she once or twice remembered or dreamed that she heard Dr Williamson, the house surgeon, speak near her. Dr Beilby, Dr Zeigler, &c., saw the case with me. The mother and child have continued perfectly well.

In this, as in other cases, I have watched and noted the effects of the chloroform upon the duration of the pains and of the intervals, the rate of the fœtal and maternal pulse, &c.

CASE XI.—Patient with a deformed spine and contracted pelvic outlet. At her first confinement two different medical gentlemen had failed in effecting delivery by the forceps. At this her second confinement, she placed herself under the care of Dr Paterson of Leigh. After being very long in labour, and the symptoms of the case becoming urgent, I saw her with Dr Paterson. The head was low down in the pelvis; but it was placed in the right occipito-posterior position (the third of Naegele), and the forehead instead of the vertex was presenting, one orbit being easily felt behind the symphysis pubis. It had been lodged in nearly the same position for many hours. The fœtal heart was still distinct, but weak. I applied the forceps—turned the head round with them a quarter of a circle, into an occipito-anterior position (the second of Naegele); and, after being so adjusted, it still required considerable force to extract it. Before applying the forceps the patient was sent into a state of deep anæsthesia by the inhalation of chloroform; and subsequently, when she wakened out of it, she was in no small degree surprised to find that she had really been delivered while she was sleeping and resting so soundly. The placenta separated, and the uterus contracted firmly. The child, which was large, lived for eight hours after delivery; but, despite of all the measures tried, full and perfect respiration was never established in it, apparently in consequence

of some effusion or injury about the base of the brain. Unfortunately a post-mortem examination was not obtained. The mother has made an excellent recovery.

I quote the following instance of craniotomy under chloroform from a letter (dated 29th November), which I have received from my friend, Professor Murphy of London. I give the case in Dr Murphy's own words:—

CASE XII.—"I have tried the chloroform with great success in a case of distorted pelvis. It was the ovate deformity, the conjugate measurement being only 2½ inches; the head of the child could not enter the brim: and I was obliged to perforate. I got Dr Snow to assist me in bringing her under the influence of chloroform. She made some resistance, and struggled a good deal at first, chiefly I think from apprehension that we were going to do something very dreadful; however she soon began to inhale quietly, and gradually fell into a kind of dreamy sleep. I perforated the head, and laboured with the crochet (sometimes with the craniotomy forceps) for three quarters of an hour before I could get the head through the brim. She was at length delivered, the placenta was separated in about ten minutes; the bandage applied, soiled clothes removed, and she was made 'clean and comfortable,' as the midwives say. My patient was perfectly unconscious all this time, and did not awake for about a quarter of an hour after the operation; she did so then quite quietly, and was greatly surprised to find that all her miseries were over. There was no hemorrhage, but the uterus felt rather spongy and large. She is now recovering most favourably. I never had a case recover so far, so well."

Other cases, both of natural and morbid labour, in which the patients were delivered in an anæsthetic state from the inhalation of chloroform, have been reported to me by Dr Protheroe Smith, Dr. Imlach, Dr Robertson of Birkenhead, Dr Malcolm, Dr Buchanan, &c.; but as these, and some other instances which I have myself seen, presented nothing new or different in their phenomena from the cases which I have already detailed, I have thought it unnecessary to overload the present communication by the details of them.

THE END

CORRESPONDENCE

RECOVERY WARDS

Sir,—I would be very glad to hear from colleagues who have experience of working in association with "Recovery Wards". In particular information is required as to allocation of (limited) space between beds and "open space" for trolleys bearing short-stay patients; nursing staff requirements (status and numbers) relative to patient-capacity of Ward; medical responsibility for organization and daily running of Ward.

V. TORRY BAXTER
Bristol Royal Hospital

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